SPECIFICATIONS

FOR

TRIPLE-EXPANSION

TWIN-SCREW PROPELLING MACHINERY

FOR

U. S. S. MAINE,

AN ARMORED CRUISER

OF ABOUT 6,600 TONS DISPLACEMENT.

BUREAU OF STEAM ENGINEERING,

NAVY DEPARTMENT,

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SPECIFICATIONS

FOR

Vertical Twin-Screw Triple-Expansion Engines,

WITH

BOILERS AND AUXILIARY MACHINERY,

FOR

U. S. S. MAINE,

OF ABOUT 6,600 TONS DISPLACEMENT.

REFERENCE BEING HAD TO THE DRAWINGS ACCOMPANYING AND FORMING PART OF THESE SPECIFICATIONS.

GENERAL DESCRIPTION.

The propelling engines will be rights and lefts, placed in water-tight compartments and separated by a fore-and-aft bulkhead. These engines will be of the vertical inverted-cylinder direct-acting triple-expansion type, each with a high-pressure cylinder 35½ inches, an intermediate cylinder 57 inches, and a low-pressure cylinder 88 inches in diameter; the stroke of all pistons being 36 inches. The collective indicated horse-power of propelling, air-pump, and circulating

pump engines will be 9,000 when the main engines are making about 132 revolutions per minute. All cylinders will be steam-jacketed. The high-pressure cylinder of each engine will be aft and the low-pressure cylinder forward, the low-pressure cylinders being so arranged as to be disconnected when working at low power. The main valves will be of the piston type, worked by Stephenson link motions with double-bar links. The piston-valves, valve-liners, and valve-gear will be made interchangeable. There will be one piston-valve for each high-pressure cylinder, two for each intermediate-pressure cylinder, and three for each low-pressure cylinder. Each main piston will have one piston-rod, with a cross-head working in slipper guides. The framing of the engines will consist of hollow cast-steel columns, trussed by wrought-steel stays. The engine bed-plates will be of cast-steel, supported on wrought-steel keelson-plates built in the vessel. The crank-shafts will be made in interchangeable sections. All shafting will be hollow. The shafts, piston-rods, connecting-rods, and working parts generally will be forged of mild open-hearth steel.

The condensers will be made entirely of composition and sheet-brass. Each condenser will have a cooling surface of about 7,010 square feet, measured on the outside of the tubes, the water passing through the tubes. For each propelling engine there will be a double, horizontal, double-acting air-pump worked by a vertical compound engine. The circulating pumps will be of the centrifugal type, one for each condenser, worked independently. The propellers will be three-bladed, right and left, of manganese or aluminum bronze, or approved equivalent metal.

There will be eight single-ended steel boilers of the horizontal return fire-tube type, 14 feet 8 inches outside diameter and 10 feet long, constructed for a working-pressure of 135 pounds per square inch. They will be placed in two equal groups in two water-tight compartments, with one fore-and-aft fire-room in each compartment. Each boiler will have three

corrugated furnace-flues, 3 feet 6 inches internal diameter. The total heating surface will be about 18,800 square feet, measured on the outer surface of the tubes, and the grate surface 553 square feet. There will be in each boiler compartment an approved vertical duplex main feed-pump and a duplex auxiliary feed-pump. Each main and auxiliary feed system will be complete in itself. There will be two smoke-pipes, one for each compartment.

The forced-draft system in each compartment will consist of two blowers, which will discharge into a main air-duct under the fire-room floors, from which a branch duct will lead to the ash-pit of each furnace. Means will be provided for closing the ash-pits when under forced draft and for preventing leakage of gases out of the furnace-doors. The draft to each furnace will be regulated by means of a damper.

There will be steam reversing-gear, ash-hoists, turning-engines, auxiliary pumps, engine-room ventilating-fans, a combined windlass and capstan, steam-winches, a steering-engine, engine and dynamo for working various small machinery and for lighting engine and fire-rooms, hydraulic pumping plant for various purposes, turret-turning engines, a distilling apparatus, and such other auxiliary or supplementary machinery, tools, instruments, or apparatus as are described in the following detailed specifications or shown in the accompanying drawings.

CYLINDERS.

They will consist of casings of best quality of cast-iron, with working linings for cylinders and valve-chests. The cylinder casings will include the valve-chests, steam ports and passages, the lower heads, and the various brackets to which the cylinder-supports will be attached. The steam and exhaust ports will be smoothly cored to the dimensions shown in drawings, the walls of the passages being strongly stayed by ribs.

The flanges for securing the cylinders to each other will be so faced that when bolted together the centers of the cylinders will be 7 feet 9 inches apart, with the cylinder-axes all in one plane and parallel. The cylinder casings will be bolted together by $1\frac{1}{2}$-inch body-bound steel bolts; twelve for the joint between high-pressure and intermediate cylinder, and thirteen for that between the intermediate and low-pressure.

HIGH-PRESSURE CYLINDER CASINGS.

The head will be cast with double walls and the barrel will be 1 inch thick. It will be faced and bored, as shown, for the reception of the working cylinder lining and for the valve-chest linings. The brackets at the bottom for attachment of the supporting columns will be well ribbed and truly bored and faced for the columns, bolts, and nuts. There will be flanges for bolting to the intermediate cylinder, these being faced to a plane parallel to the axis of the cylinder. The walls of the steam passages will be properly stayed. There will be facings, flanged and ribbed where necessary, for the attachment of the cylinder and valve-chest covers, stop-valve, exhaust-pipe, cross-head guide, piston-rod stuffing-box, relief-valves, drain-cocks, indicator-pipes, jacket steam and drain-pipes, oil-cups, starting-valve pipes, and starting-valve chest.

INTERMEDIATE CYLINDER CASINGS.

They will be fitted similarly to the high-pressure casings, except in the following particulars. It will have two piston-valves. It will have faced flanges for bolting to the high and low-pressure cylinders. There will be a man-hole in the cylinder-head. The barrel of the casing will be $1\frac{1}{8}$ inches thick. There will be faced brackets for the supporting columns and diagonal brace, also facings for man-hole cover, steam and exhaust-pipes, jacket and receiver safety-valves, and receiver live steam-pipe. There will also be facings for attaching the bracket-bearings for the valve-motion rock-shaft, starting-valve pipes, and for starting-valve chest.

The walls of the steam ports will be stayed, where ribs would offer too much obstruction, by screwed stay-bolts with ends riveted over.

LOW-PRESSURE CYLINDER CASINGS.

Each will be of the same material as that of the high-pressure casing and similarly fitted, except in the following particulars. It will have three piston-valves. It will have a man-hole in the cylinder-head. It will have faced flanges on the after side for bolting to the intermediate casing, and proper lugs and brackets cast on the head for the bracket-bearings for valve-motion rock-shaft. The barrel of the casing will be $1\frac{3}{8}$ inches thick. There will be faced brackets for the supporting columns and diagonal brace, also facings for man-hole cover, two low-pressure steam and one exhaust-pipe, auxiliary exhaust-pipe, jacket, and receiver safety-valves, receiver live-steam pipe, starting-valve pipes, and starting-valve chest.

CYLINDER LININGS.

They will be of cast-steel or close-grained cast-iron as hard as can be properly worked, turned and faced to fit the cylinder casings. Each lining will have a bearing at about the middle of its length.

The linings will have inward flanges at bottom and be secured by square-headed countersunk steel collar-screws tapped into the cylinder casings.

The joint at upper end of each liner will be made tight, with allowance for expansion, by a copper ring about $\frac{1}{16}$ inch thick. This copper ring will be backed by a wrought-iron ring $1\frac{1}{4}$ inches wide and $\frac{1}{2}$ inch thick, the two rings together being secured to the cylinder liner by $\frac{5}{8}$-inch wrought-iron screws, spaced not over 3 inches.

A similar backing-ring and screws will make a tight joint between the same copper ring and the facing provided on the cylinder casing. The facings of lining and casing will be cut

away under the middle of the copper ring and the edges of the backing-rings chamfered to allow of free expansion.

The linings, after being secured in place in the casings, will be smoothly and accurately bored to diameters of 35½, 57, and 88 inches, and to thicknesses of 1⅛, 1⅛, and 1¼ inches for the high, intermediate, and low-pressure cylinders respectively, the boring to be done with the cylinders in a vertical position. The linings will be counterbored at lower ends, leaving the working bores 38½ inches long.

CYLINDER COVERS.

They will be of the same quality of cast-iron as the cylinder casings, and cast with double walls, 1 inch thick, well stiffened by ribs of the same thickness, each cover with a 17½-inch man-hole. They will be so formed as to leave as little clearance as practicable.

Pockets will be cored for the heads of the piston-follower bolts. Each cover will be turned and faced to fit its cylinder casing, bored and faced at man-hole, finished on outside of flanges, and rough-finished elsewhere on outside.

The cover of the high-pressure cylinder will be secured to the cylinder casing by twenty-four 1⅜-inch steel studs, the cover of the intermediate by thirty-six 1¼-inch studs, and the low-pressure covers by forty-four 1¼-inch steel studs.

Holes will be drilled and tapped for jack-bolts and eye-bolts.

CYLINDER MAN-HOLE COVERS.

They will be of cast-iron, cored for clearance of piston-rod nuts, turned and faced to fit man-holes, and finished on the outside of flanges. They will be secured by 1-inch steel studs, spaced as shown in the drawings, and will have holes drilled and tapped for jack-bolts.

A covering plate, finished outside, will be fitted on the top of each man-hole cover and secured by a central eye-bolt.

CYLINDER CLEARANCES.

Care will be taken that the clearances in the cylinders are made no larger than absolutely necessary. After the engines are set up in place and connected, the volume of the clearance at each end of each cylinder will be carefully measured by filling the space with water or oil, and the result plainly marked on some conspicuous part of the cylinder's casing. Marks will also be made on the cross-head guides showing the position of the pistons where the clearances were measured.

STEAM-JACKETS.

The cylinders will be steam-jacketed on top, sides, and bottom.

The space left around the working linings for steam-jackets will not be less than 1 inch in depth. All ribs must be cored out so as to allow a free circulation of the jacket-steam and a free drainage of the water of condensation.

Steam for the jackets will be taken from the main steam-pipe in each engine-room, on the boiler side of the engine stop-valve, by a 3-inch pipe. From this pipe a 1-inch branch will lead to the high-pressure cylinder-cover jacket and a $1\frac{3}{4}$-inch branch to the barrel-jacket. A 2-inch branch, with a 2-inch adjustable-spring reducing-valve, adapted to pressures of from 20 to 80 pounds, will lead to the intermediate-pressure cylinder, with branches to head and barrel-jackets of the same size as those for the high-pressure cylinders.

Another 2-inch branch will have an adjustable-spring reducing-valve, adapted to pressures of from 0 to 30 pounds, and branches to the low-pressure jackets, as in the other cylinders.

Each branch steam-pipe will have a stop-valve close to jacket.

There will be on the intermediate jacket steam-pipe, on the jacket side of the reducing-valve, a 2-inch adjustable-spring safety-valve, adapted to the same pressures as the reducing-

valve, and on the low-pressure jacket steam-pipe a similar valve, adapted to the jacket pressure.

A 1-inch brass drain-pipe will pass through a hole in the wall of each cylinder and be screwed into the lowest part of the cylinder cover, the joint on the outside of the cylinder being made tight by a brass nut and washer. This pipe will join a 1¼-inch drain leading from the lowest part of the main jacket. From the junction of these pipes a 1½-inch pipe will lead to an approved automatic trap with blow-through and by-pass pipes and valves, thence to the lower part of the feed-tank, with a branch to the bilge. Each drain-pipe will have a stop-valve close to its jacket. The drainage system of the jacket of each cylinder will be entirely independent as far as the trap-discharge, from which point the drains may be in common. All pipes in the jacket-drain system will be put together by union joints so as to be easily overhauled.

VALVE-CHESTS.

The valve-chest of each high-pressure cylinder will be fitted for one piston-valve, each intermediate-pressure for two, and each low-pressure for three.

There will be openings at each end for inserting and removing the valves and working-linings. The ports will be accurately bored and lined for the reception of the working-linings.

Before the insertion of the linings the steam and exhaust passages must be thoroughly cleaned out and care taken that the passages are not in any case contracted to less than the specified areas.

Each intermediate and low-pressure valve-chest will have a 3-inch self-relieving safety-valve of approved pattern.

All valve-chests will also be fitted with suitable separate drain-cocks or valves that may be operated from the working platform. The valves to discharge through pipes into the bilge and feed-tanks with the necessary valves for directing the water to either.

VALVE-CHEST LININGS.

There will be a working-lining at each end of each valve-chest for each piston-valve. They will be of cast-steel or close-grained cast-iron as hard as can be properly worked, accurately turned and faced to fit the casings, and accurately bored to an internal diameter of 22 inches, leaving the walls 1 inch thick.

They will be forced into place, making all joints perfectly tight, and secured by screws tapped half into the linings and half into the casings.

The upper linings of all valve-chests will be alike and interchangeable, the lower linings also being alike and interchangeable.

The steam-ports at each end will be $3\frac{7}{8}$ inches wide.

The bores of the upper linings will extend $7\frac{17}{64}$ inches beyond the ports on the steam side and $4\frac{15}{16}$ inches on the exhaust side; the bores of the lower linings will extend $6\frac{59}{64}$ inches beyond the ports on the steam side and $5\frac{5}{8}$ inches on the exhaust side.

The steam-ports will have alternating right and left diagonal bridges, each not less than $\frac{7}{8}$ inch wide, leaving a clear port opening of 203 square inches in each valve-lining.

The edges of all ports will be finished to a uniform outline.

VALVE-CHEST COVERS.

They will be made of cast-steel, in dished form, excepting the high-pressure valve-chest covers, which will be flat. All will be ribbed, as shown in drawings.

The flanges will be turned and faced to fit the openings in valve-chests. The covers will be finished on the outside. Each lower cover will have a stuffing-box cast in, with an extension, as shown, to form a guard for the valve, to prevent the rings from over-riding the seats when disconnected. There will be a composition bushing, well secured, at the inner end of the stuffing-box, this bushing to be grooved circumferentially.

Sufficient metal will be left at the side of the stuffing-box for a ½-inch oil-passage, this passage to be drilled from the outside of the cover and to communicate with the upper circumferential groove of the bushing.

Each upper cover, except that of the high-pressure valve, will have an interior sleeve cast on, which will be bushed with composition, the bushing to be grooved the same as that in lower cover, and well secured in place. A ½-inch oil-passage will lead from the upper part of this bushing to outside of the cover. Each upper cover will have a smaller finished cast-steel cover, flanged and bolted on, over the upper end of the valve-stem.

The upper cover of each high-pressure valve-chest will have a cylinder cast on, bored out to 8 inches in diameter for a length of 13½ inches. In this cylinder will work the balancing-piston of the high-pressure valve, with the steam on the under side of the piston. A suitable opening in the cover will be made for the escape of any steam that may pass the piston. The balancing-piston will be of composition with cast-iron packing-rings.

Each valve-chest cover will be secured by sixteen 1⅛-inch steel studs, with finished wrought-iron nuts.

PISTON-VALVES.

They will be of composition, with a general thickness of ⅜-inch, each made in two parts, all interchangeable. Each of these parts will consist of a hollow piston, with follower, wearing-ring, and two packing-rings.

The followers will be of composition, secured in place by steel through-bolts, with wrought-iron nuts and brass split-pins. The follower-bolts will pass through lugs on the inside of the valve-shell and have their heads so formed and fitted as to prevent turning. The wearing-rings will be of cast-iron, finished to a neat end fit between the valve-body and follower, but to a loose side fit. They will be smoothly and accurately turned and faced for the reception of the packing-rings. The

packing-rings will be of the best cast-iron, turned larger than the bore of valve-seat, cut obliquely, tongued and sprung into place, and set out by springs of approved pattern. The rings will be $1\frac{1}{4}$ inches wide and $\frac{7}{8}$ inch thick for the upper part of each valve, and $1\frac{3}{8}$ inches wide and $\frac{7}{8}$ inch thick for the lower part, as shown.

The two parts of each valve will be separated, when in place on their valve-stem, by a cast-steel distance-piece, which will be of such lengths as to make the steam and exhaust laps as follows:

Steam lap—top, $2\frac{3}{64}$ inches; bottom, $2\frac{5}{64}$ inches.

Exhaust lap—top, $\frac{3}{16}$ inch; bottom, $\frac{7}{8}$ inch.

Distance from steam edge to exhaust edge—top, $6\frac{37}{64}$ inches; bottom, $6\frac{53}{64}$ inches.

VALVE-STEMS.

They will be of forged steel, $2\frac{3}{4}$ inches in diameter at the stuffing-boxes and reduced to 2 inches where they pass through the valves. The lower end of each stem will have a $2\frac{1}{4}$-inch thread cut on it and be fitted with two steel nuts for securing it to the cross-head. A slot will be cut in the thread on each stem and fitted to a feather in the cross-head. The nuts will have collars recessed in counterbores in the cross-heads and secured by set-screws. The thread on each stem must be sufficiently long to allow a reasonable latitude of adjustment. The top of each stem will be finished with a $1\frac{1}{2}$-inch right-hand thread and a 1-inch left-hand thread. The $1\frac{1}{2}$-inch thread will be fitted with a composition nut which will be set up on a steel wearing-sleeve which surrounds the valve-stem and bears against the top of the valve. The 1-inch thread will be fitted with a nut to lock the main nut in place.

CYLINDER RELIEF-VALVES.

There will be an adjustable spring relief-valve on each end of each main cylinder of the following diameters: High-pressure relief-valves, $3\frac{1}{2}$ inches; intermediate relief-valves,

3½ inches; low-pressure relief-valves, 5 inches. The valves and their casings will be of composition. Pipes will lead from the relief-valves to the bilge with easily-broken joints.

These valves will have nickel seats or their equivalent, and the valve-fittings will be so constructed that the valves can be easily overhauled without slacking the springs and so that steam will not come into contact with the springs. The springs will have approved means of adjustment, and will be long enough to allow the valves to open to their full extent without unduly increasing the load. The valves will be guided by loosely-fitting wings. The springs will bear on shoulders on spindles which fit loosely in sockets recessed in the backs of the valves. These spindles will be so fitted that the valves can be moved by the application of a lever. The valves will be fitted with casings, which will prevent danger of people being scalded by hot water from the cylinders. Suitable fulcrums will be on casings for the application of levers for working the valves; one lever to be furnished for each engine-room. All springs must pass a satisfactory test.

The spring-casing of each valve will be fitted with a suitable lock; all locks to have similar keys.

CYLINDER-DRAIN COCKS.

Each cylinder will be fitted with a 2-inch packed drain-cock, placed so as to drain the cylinder thoroughly. The cocks must be perfectly tight without undue friction. The drain-cock of each cylinder of each engine will be worked by a single lever at the working-platform. All the drain-cocks of each engine will discharge into a pipe leading to the fresh-water side of the condenser, with a branch to the bilge. This pipe will have a stop-valve near the condenser, and will have a spring non-return valve, without hand-gear, which can open to the bilge discharge when the drain to condenser is closed, but which will prevent air entering the condenser at any time. Small drain-cocks will be fitted to the lowest parts of drain-pipes.

ENGINE THROTTLE-VALVES.

Each engine will have a throttle-valve, bolted to the high-pressure cylinder casing. Each throttle will consist of two gridiron slide-valves, one above the other. The slide nearest the seat will be worked by a steam-piston, working in a cylinder, whose valve will be controlled by a floating-lever so fitted that the throttle-valve will follow the movement of a hand-lever at the working-platform. This throttle will have a locking-gear, worked from the platform, which will hold the valve wide open when desired. Steam for the controlling cylinder will be taken from the auxiliary steam-pipe, with a stop-valve easily reached from the working-platform.

The upper throttle-slide will be worked by a screw-stem, the gear operating the stem being worked by an 18-inch hand-wheel at the platform, where it will have an index, divided as directed.

The steam-actuated throttle is intended for use in quick working, and the hand-moved valve for fine adjustment.

The spindles of both valves will be horizontal. The valves, stems, and casings will be of composition. The casing will be made in two parts, divided near the plane of the valve-face.

STARTING-VALVES.

There will be a starting-valve for each cylinder of the propelling-engines on the inboard side above the working-platform. These will be piston-valves; each complete in itself, with both steam and exhaust-ports. The valves, chests, and covers will be of composition. The valves must be securely fastened to their stems. The valve-chests will be bolted to the facings provided for them. Steam for the starting-valves will be taken from the main steam-pipes outside the throttle-valves by a pipe having a branch to each valve. There will be a stop-valve in this pipe, to be worked from the working-platform; also a stop-valve close to each valve-

chest. Each starting-valve will connect with each end of its cylinder by a 2-inch copper pipe. These valves will all exhaust into a 2-inch pipe leading to the condenser, the branch from each valve having a stop-valve close to the valve-chest. Each steam-port of each starting-valve will have an area of about 3 square inches. Each starting-valve will be worked by a lever at the working-platform; these levers to be placed in the same order as their respective valves, and arranged to move in the same direction as the desired motion of the piston. The valves are to be in middle position when their levers are vertical.

PISTON-ROD STUFFING-BOXES.

They will be made of composition, and fitted with approved metallic packing with efficient means of lubrication. The packing of each stuffing-box will be made in two independent sections, so that in case of injury to one section the other alone will make a tight joint; this packing to be in all respects equal to Watson's.

VALVE-STEM STUFFING-BOXES.

They will be cast in the lower covers of valve-chests, and will be fitted with metallic packing of the same kind as used for piston-rod stuffing-boxes.

PISTONS.

They will be of composition, with double shells, well ribbed. The metal in the shells will be $\frac{1}{2}$ inch thick and that in the bosses around piston-rods $1\frac{3}{4}$ inches.

The followers, made as shown in the drawings, will be of composition, with flanges $1\frac{1}{8}$ inches thick, secured in place by $1\frac{1}{4}$-inch bolts, 8 for each high, 14 for each intermediate, and 20 for each low-pressure piston.

The follower-bolts will be steel studs, screwed into the pistons; the bodies of the studs to be square, passing through square holes in the followers. The follower-bolt nuts will be of wrought-iron, finished and case-hardened, each nut to be secured in place by a brass split-pin of ample size.

Each piston will have 2 packing-rings, each $\frac{5}{8}$ inch wide and $\frac{5}{8}$ inch thick, of hard cast-iron, cut obliquely and tongued.

The packing-rings will be set out by steel springs of approved pattern, all set to an equal and proper tension. They will bear against a flanged cast-iron floating ring which will be so fitted as to allow an easy play in the piston. There must be sufficient clearance at the back of the floating ring to allow of proper play, in addition to clearance to allow of the greater expansion of the piston. There will also be sufficient clearance between the piston and cylinder to allow for difference of expansion.

Each packing-spring must be so secured in the floating ring as to be firmly held in place and easily inserted and removed. The springs must be of best spring-steel, properly tempered.

When completed the pistons must be carefully weighed, and no excess of weight will be allowed over that due to the dimensions shown in the drawings. The cores must be thoroughly cleaned out, core-plugs screwed in and locked, and the pistons tested for tightness. All core-plugs must be either in peripheries or on top of pistons.

PISTON-RODS AND CROSS-HEADS.

The piston-rods will be of forged steel, $6\frac{1}{4}$ inches diameter. They will be turned to fit the pistons, with collars, as shown, and fitted each with a composition closed nut secured by a screwed stop-pin. The parallel parts will be smoothly and accurately turned. The lower end of each piston-rod will be enlarged to form a cross-head, and will be fitted with an adjustable brass, and a composition cap, secured by steel bolts with wrought-iron nuts and loose collar-keepers with set-screws. The brass and cap will be properly bored and faced to suit cross-head pin.

The bolts for cross-head cap will be of forged steel $3\frac{3}{4}$ inches diameter.

Each piston-rod will have, at its seating in the piston, a collar 8 inches diameter and $2\frac{1}{2}$ inches thick, well filleted, and recessed in the piston as shown.

CROSS-HEAD SLIPPERS.

A wrought-iron slipper will be dovetailed and shrunk on each cross-head and further secured by tap-bolts as shown. The slipper will be finished all over. A composition guide-gib, 22 inches long by 20 inches wide, in two parts, will be fitted to each slipper, secured at lower ends by a flange and studs and at the upper ends by square-headed bolts in slotted holes. Each gib will be finished with white-metal slabs, dovetailed, hammered in place, and provided with oil-grooves.

CONNECTING-RODS.

The connecting-rods, with their caps and bolts, will be of forged steel, finished all over.

They will be 72 inches long between centers, turned $6\frac{1}{2}$ inches in diameter at small end and 10 inches at large end, the sides being faced off to a uniform thickness of $6\frac{1}{2}$ inches.

The cross-head end of each rod will be forked to span the cross-head brasses, and each eye at that end will be split and fitted with a bolt for gripping the cross-head pin, and will be bored $8\frac{1}{2}$ inches.

The cross-head pin will be of forged steel, finished to a neat fit, inserted in the eyes and securely clamped.

The crank-pin end of each connecting-rod will be increased in thickness to 10 inches, faced on each side, and bored $17\frac{1}{2}$ inches in diameter for the brasses. The caps will be $4\frac{1}{4}$ inches thick at the crown, each to conform to the shape of the connecting-rod end. The bolts will be $3\frac{3}{4}$ inches in diameter; the heads to be fitted with stop-pins and the upper ends of bolts to be provided with split-pins of ample size outside the nuts. The nuts will be of wrought-iron, each with a collar recessed into the connecting-rod head and secured by a set-screw. The cap-bolts will pass partly through the crank-pin brasses and will be fitted with set-screws for holding their weight when backing off the nuts.

In each jaw and each cap of each connecting-rod, two $1\frac{3}{8}$-inch bolts will be fitted, passing through the metal of the rods

and caps and tapped into the corresponding lip of the crank-pin brasses to prevent closing-in when heated, each of these bolts being secured by a set-screw.

Composition distance-pieces will be fitted between the connecting-rods and caps; they will be so fitted as to be removable without taking out the cap-bolts, and will be channeled so as to be easily reduced when taking up lost motion.

The caps will each be fitted with two eye-bolts for handling.

CRANK-PIN BRASSES.

They will be accurately fitted to the connecting-rods and secured as before specified. They will be fitted with approved white-metal in strips, accurately fitted to the crank-pins, and properly fitted for distribution of oil. They will be $1\frac{3}{4}$ inches thick and faced with sufficient clearance between crank-webs to prevent nipping when heated.

ENGINE-FRAMES.

Each high and each low-pressure cylinder will be supported upon four hollow cast-steel columns 7 inches outside diameter; the metal to be 1 inch thick. The intermediate cylinder will be supported upon two columns of the same dimensions as above, and also upon an inverted Y column as shown in drawing. The upper ends of the columns for high-pressure cylinders will terminate in collars 10 inches diameter and not less than $1\frac{3}{4}$ inches thick, turned, faced, and counterbored to match the bosses on brackets of cylinder-casings. The high-pressure columns will be fitted in place with steel screw-bolts 4 inches diameter, with collars 6 inches diameter and 1 inch thick, accurately fitting the counterbores, with steel recessed nuts as shown. The upper ends of the columns for the intermediate and low-pressure cylinders will be secured each with four 2-inch steel through-bolts, except the upper end of the inverted Y column on intermediate cylinder, which will be secured with

four 2¾-inch steel bolts. These bolts will be body-bound where possible. The lower ends of the columns will be constructed with ample flanges, faced, not less than 1¾ inches thick, secured to the bed-plates and engine foundations each by four 2-inch steel body-bound bolts. Each end of each column, except the upper ends of inverted Y columns, will be fitted with a cross-key 2 inches wide by 1 inch thick, as shown. The columns will be stayed by horizontal steel brace-rods 2¾ inches diameter, and by athwartship diagonal braces 3 inches diameter, as shown in drawings. There will also be fore-and-aft diagonal braces as shown. These braces will be passed through lugs on the bed-plates, and secured in the lugs on cylinders by caps bolted on. The braces will be set up taut by nuts on each side of lugs. The columns will have facings for carrying-brackets to support lower ends of main cross-heads guides and for the reversing-shaft bearings.

The two engines will be connected by two athwartship horizontal braces passing through the central bulkhead between the engine-rooms, each brace being in two parts, joined at center by sleeve and keys as shown. Where the braces pass through the middle-line bulkhead they will be made water-tight by approved means.

BED-PLATES.

They will consist, each, of three steel castings, flanged and bolted together, as shown. Each end-casting of each bed-plate will have a lug, the forward one for the diagonal brace to intermediate-pressure cylinder, and the after one for the diagonal brace to the low-pressure cylinder of the corresponding engine. Each jaw will be stiffened by a web 12¾ inches deep and 1¼ inches thick under it, which will extend across the casting, as shown.

The upper and lower flanges will be connected, and properly stiffened by ribs, as shown.

The bed-plates will be secured to the engine-seatings by 1⅞-inch bolts through the lower flange, and by the support-

ing column bolts which will pass through both flanges of the bed-plate and the flange of the engine-seating, and they will be properly finished and faced for crank-shaft brasses and caps and for the flanges of the supporting columns. Each jaw will be fitted with an adjustable composition chock and wedge for the vertical alignment of the shaft. The wedge in each block will be adjusted by screws of not less than 1 inch in diameter, as shown. The chocks will have flanges, as shown, to prevent end motion. The bed-plates will have facings to which the reversing engines will be bolted.

CRANK-SHAFT BRASSES AND CAPS.

The brasses for each bearing will be cylindrical, in two parts, $1\frac{7}{8}$ inches thick, lined with approved white metal, fitted with ample oil-channels, faced 14 inches long, turned to fit cap and chock, as shown, and accurately bored to fit the journals of shaft. The caps will be of cast-steel, $3\frac{3}{4}$ inches thick and 13 inches wide, with lips to match the jaws. Each cap and upper brass will have an oval hand-hole for the purpose of feeling the journal. This hand-hole will have a cover, with handle; the lower part of the cover being formed into a perforated tallow-box, reaching to within a quarter of an inch of the journal.

The cap-bolts will be of forged steel, $3\frac{1}{4}$ inches in diameter, each provided with a collar, as shown. One end of each bolt will be threaded and screwed into the engine bed-plate. The other end will be threaded and fitted with finished wrought-iron collar-nut and set-screw—the part beyond the nuts will be squared and each fitted with a split-pin.

The caps and brasses will be tapped and fitted with eye-bolts for handling.

The brasses will be prevented from pinching the journals by channel-shaped clamping-pieces, the upper ones being extended as shown in drawing to form distance-pieces and to prevent the brasses from turning. They will be doweled to the caps or chocks to prevent end motion.

After the engines are secured in the vessel the brasses will be bored out in place to perfect alignment, if required. They will also be tried on their shafts and any defects made good by scraping to a proper bearing.

The brasses will be so fitted that the only bearing of the journals will be on the surface of the white metal.

CROSS-HEAD GUIDES.

They will be made of cast-iron, each secured at one end to a bracket on cylinder and supported at the other end by a beam, which will be secured to the supporting columns as shown in the drawings. The sides will be $1\frac{1}{4}$ inches thick, each with six ribs; the bottom will be 4 inches deep and cored, as shown, for the circulation of water.

The wearing-surface will be 48 inches long and 20 inches wide, and the wall forming it will be 1 inch thick.

There will be a composition backing-guide furnished with oil-grooves bolted on each side of each cross-head guide by five $1\frac{1}{4}$-inch steel studs, and one $1\frac{3}{8}$-inch through bolt, as shown.

The guides will be smoothly and accurately finished, and will be fitted in place to proper alignment. Brass oil-boxes will be screwed to lower end of each guide.

VALVE-GEAR.

It will be of the Stephenson type, with double bar-links.

Each high-pressure valve will be worked direct, and the intermediate and low-pressure valves by rock-shafts.

Each rock-shaft will be connected to its link by an equalizing-bar whose upper end will be carried by a radius-link of such length as to minimize the slip of the link-block.

On each rock-shaft there will be an arm for working each valve. Each valve-stem cross-head will be connected to its rock-shaft arm by two valve-links.

The valve-gear will be so adjusted that the mean cut-off in full gear for both ends of each cylinder will be at 0.7 stroke.

ECCENTRICS.

They will be of cast-steel, each in two parts.

The two parts of each eccentric will be neatly fitted together and secured by two $1\frac{3}{8}$-inch bolts. They will be bored out to a snug fit on the shafts and turned accurately on the outside to an eccentricity of $4\frac{3}{4}$ inches.

They will be 3 inches, 4 inches, and $5\frac{1}{2}$ inches wide for the high, intermediate, and low-pressure valves respectively; and will be recessed at each side $\frac{1}{2}$ inch wide and $\frac{1}{2}$ inch deep for the flanges of the eccentric-straps. Each backing eccentric will be securely keyed on the shaft, and each forward-motion eccentric will be secured to the corresponding backing eccentric by through-bolts in slotted holes, the holes to be filled up after the eccentrics are set.

ECCENTRIC-STRAPS.

They will be of composition, finished all over, 2 inches thick, made with flanges to fit the recesses of eccentrics and with lugs for the clamping-bolts and for the eccentric-rods. The two parts of each strap will be held together by two steel bolts $1\frac{1}{2}$ inches diameter for the high and intermediate, and $1\frac{3}{4}$ inches diameter for the low-pressure, with finished heads, lock-nuts, and split-pins, and fitted with channeled brass distance-pieces. Each strap will be accurately and smoothly bored to fit the eccentrics, both on face and recesses, and properly channeled for oil.

ECCENTRIC-RODS.

They will be of forged steel, finished all over. Each rod will have a T-head secured to its eccentric-strap by two steel stud-bolts $1\frac{1}{2}$ inches diameter for the high and intermediate, and $1\frac{3}{4}$ inches for the low-pressure, with nuts locked in place.

The upper end of each rod will be forked to span the link and fitted with brasses, straps, gibs, and keys, as shown in drawings, which will be interchangeable for all the rods.

The two brasses in the forks of each rod must be fitted accurately in line with each other and smoothly bored to fit the link-pins. The distance from centers of eccentrics to centers of link-pins will be 72 inches.

MAIN-LINKS.

They will be of double-bar pattern, of forged steel, finished all over. The bars will be $1\frac{1}{2}$, $1\frac{5}{8}$, and $1\frac{3}{4}$ inches thick for the high, intermediate, and low-pressure valves respectively, and all 5 inches wide, with the pins for eccentric-rods forged on and finished to $3\frac{1}{4}$ inches diameter and $2\frac{3}{4}$ inches long, the pins to be spaced 24 inches from center to center. Each pair of bars will be secured together by through bolts and thimbles, fitted with finished steel-nuts with $1\frac{3}{4}$-inch thread; and will be $5\frac{1}{2}$ inches from face to face inside for the high and intermediate-pressure cylinders, and 6 inches from face to face for the low-pressure cylinders.

LINK-BLOCKS.

They will be of forged steel, finished all over. The blocks will be forged with link-block pins $3\frac{1}{2}$ inches diameter and $3\frac{1}{2}$ inches long for the high and intermediate-pressure valves, and $4\frac{1}{2}$ inches diameter and 4 inches long for the low-pressure valves.

They will terminate at each end in a pair of jaws 8 inches long, to span the corresponding bar on the link. These jaws will be fitted with composition gibs 10 inches long, finished to the curve of the links, the upper gib in each jaw being fitted with a key with screw adjustment.

SUSPENSION-LINKS.

Each Stephenson link will be suspended from the corresponding arm of the reversing-shaft by two flat-sided, forged-steel suspension-links; the intermediate and high pressure to be 3 feet 8 inches long between centers, and the low pressure 4 feet 8 inches; all to be 2 x 1 inch section.

The ends of these links will be fitted with composition bushings, bored to fit suspension-pins on main links and pins on reversing-shaft arms.

EQUALIZING-BARS.

The bars connecting the intermediate and low-pressure links with the rock-shaft arms will be of cast-steel, each fitted as shown, with brasses with wedge adjustment to connect with the link-block pin, with brasses with wedge adjustment to connect with the pin on the rock-shaft arm, and with composition bushings, to connect with the radius-links. The adjustable brasses will be bored $3\frac{1}{2}$ inches and faced $3\frac{1}{2}$ inches for the intermediate-pressure bars, and bored $4\frac{1}{2}$ inches and faced 4 inches long for the low-pressure bars. The bushings at the upper ends will be bored $2\frac{1}{2}$ inches diameter and faced $2\frac{1}{2}$ inches long for the intermediate bars, and bored 3 inches diameter and faced $3\frac{1}{4}$ inches long for the low-pressure bars. The middle and lower bearings will be 11 and $18\frac{1}{2}$ inches from center to center for the intermediate and low-pressure bars respectively, and middle and upper bearings $9\frac{1}{2}$ inches from center to center for the intermediate and low-pressure bars.

RADIUS-LINKS.

There will be two radius-links to guide the upper end of each equalizing-bar. They will be of forged-steel, finished $13\frac{3}{4}$ inches between centers for the low-pressure gear, and $10\frac{5}{16}$ inches for the intermediate. Each pair of links will be connected at each end by a pin, as shown. These pins will be 3 inches diameter for the low-pressure gear, and $2\frac{1}{2}$ inches diameter for the intermediate.

The fixed center for the radius-links for the low-pressure gear will be cast on the forward bearing-bracket of low-pressure valve rock-shaft, and will be bushed and bored to a diameter of 3 inches and faced $3\frac{1}{4}$ inches long.

That for the intermediate gear will be in a separate bracket, bolted to facings on the lower head of intermediate cylinder, as shown. It will be bushed and bored to a diameter of $2\frac{1}{2}$ inches and faced $2\frac{1}{2}$ inches long.

VALVE-MOTION ROCK-SHAFTS.

They will be of forged-steel, finished all over, the arms to be made separately of cast-steel, also finished all over.

Each low-pressure rock-shaft will be carried in four bearings, the journals being 4, 4¾, 5½, and 7 inches in diameter.

Each intermediate rock-shaft will be carried in two bearings, the journals being 4¾ and 6 inches in diameter.

Each low-pressure rock-shaft will have four arms, one to connect with the link-motion and the others connecting with the valves.

Each intermediate rock-shaft will have three arms, one to connect with the link-motion and the others connecting with the valves.

All these arms will be 22¾ inches between centers.

The arms connecting with the link-motions will each carry a pin turned to the following dimensions: Intermediate, 3½ x 3½ inches, and low-pressure, 4½ x 4 inches.

The arms connecting with the valve-stems will each have a jaw to span the valve-stem, each side having a pin turned 2 inches diameter and 2 inches long.

Each arm will have a boss which will be bored to a snug fit on its rock-shaft, to which it will be securely keyed, as shown in the drawings. Keys will have T-heads wherever possible.

VALVE-MOTION ROCK-SHAFT BEARINGS.

The valve-motion rock-shaft bearings will consist of brackets bolted to facings on cylinder-heads, as shown in drawings. The brackets will be made of cast-steel and fitted with brasses; the caps will be of composition, held in place by steel studs screwed into brackets and fitted with finished wrought-iron nuts.

The brasses will be accurately bored out to fit the rock-shafts and be adjusted to perfect alignment. The brasses for the low-pressure bearings will be bored out to diameters of 4, 4¾, 5½, and 7 inches, with lengths of 4, 4, 4, and 6 inches

respectively, and those for the intermediate-pressure rock-shafts to diameters of $4\frac{3}{4}$ and 6 inches, with lengths of 4 and $5\frac{1}{2}$ inches respectively.

The forward bracket for the low-pressure rock-shaft will have a boss cast on it for the fixed center of the low-pressure radius-links. This boss will be bushed and bored to a diameter of 3 inches and faced $3\frac{3}{4}$ inches long.

VALVE-STEM CROSS-HEADS.

They will be of cast-steel, finished all over. Those for the intermediate-pressure and low-pressure valve-stems will have at each end a pin 2 x 2 inches. The boss of each cross-head will be bored to fit the lower end of valve-stem, and will have a key-way to fit the feather on same.

Each high-pressure cross-head will be fitted with adjustable composition gibs, which will work in cast-steel guides bolted to the valve-chest cover, and also with the link-block brasses, adjustable by a wedge, as shown.

VALVE-LINKS.

There will be two valve-links of forged steel, finished all over, for each valve of intermediate and low-pressure cylinder. They will be 8 inches long between centers. The end connecting with valve-stem will be fitted with a composition bushing; the end connecting with the rock-shaft arm will have adjustable brasses.

REVERSING GEAR.

The reversing gear for each engine will consist of a steam cylinder and a hydraulic controlling cylinder placed vertically and acting directly on an arm fixed on the reversing-shaft.

The steam-cylinder will be 20 inches diameter, and the controlling cylinder 9 inches diameter, with a stroke of about 27 inches. They will be placed on the inboard side of each

engine, opopsite the space between the intermediate-pressure and low-pressure cylinders, and secured to engine-frames and bed. The steam piston-rod will be secured to a steel cross-head at lower end, working in suitable guides and connecting with the arm on the reversing-shaft. The piston-rod on the upper end will pass through the controlling cylinder with uniform diameter. The controlling cylinder will be of composition. The valve of the steam cylinder will be of the piston pattern, of composition, working in a composition-lined valve-chest. There will be a by-pass valve on the hydraulic cylinder, which will be worked by a continuation of the stem of the steam piston-valve. These valves will be worked by a system of differential levers, the primary motion being derived from the hand-lever on the working-platform and the secondary motion from a pin on the reversing-arm, all parts being so adjusted that the reversing-engine shall follow the motion of the hand-lever, and be firmly held when stopped. There will be a stop-cock in the by-pass pipe of the hydraulic cylinder, and a pump for reversing by hand will be connected to the hydraulic cylinder, with its lever convenient to the working-platform. The by-pass pipes will pass through the valve-box of the hand-pump in such a way as to leave the hand arrangement always in gear. The piston of the hydraulic cylinder will be packed by two cup-leathers. Steam for the reversing-engine will be taken from the auxiliary steam-pipe.

REVERSING-SHAFTS.

There will be two forged-steel reversing-shafts, one for reversing the high-pressure and intermediate links, and one for reversing the low-pressure link. The former will have three arms, one connecting with the reversing-engine and the other two connecting with the high-pressure and intermediate links. The latter shaft will have two arms, one connecting with the low-pressure link and the other connected to the reversing-engine arm of the first-mentioned shaft by a link 8⅞ inches long between centers, as shown in the drawing. The high and

intermediate-pressure shafts will be supported by four bearings, and the low-pressure shaft by two bearings. Each reversing-arm will be made with a slot, fitted with a composition block, to which the suspension-rods will be attached. Each block will be adjustable in the slot of its arm by a screw and hand-wheel with approved locking device, and will be fitted with a suitable index. The slots in these arms will be so arranged that the links may always be thrown into full backward gear irrespective of the position of the block in the slot; and the length of the slots will be such that the cut-off may be varied from 0.5 to 0.7 of the stroke. All the arms will be neatly fitted and keyed to the shafts. The reversing-shafts will be finished to dimensions as shown in drawings.

REVERSING-SHAFT BEARINGS.

They will be made of cast-steel, with bottom brasses and composition caps, and will be securely bolted to the supporting columns with collar-bolts, which will also secure the caps to the blocks with lock-nuts. They will be bored to fit the journals of the shafts as follows: For each high and intermediate-pressure shaft, one bearing $5\frac{1}{2}$ inches diameter and 8 inches long, and three bearings $3\frac{1}{2}$ inches diameter and 6 inches long. For each low-pressure shaft there will be two bearings $5\frac{1}{2}$ inches diameter and 8 inches long.

EXHAUST-PIPES.

A 13-inch pipe will lead from the exhaust side of each high-pressure valve-chest, with a 13-inch branch to each end of the valve-chest of the corresponding intermediate cylinder. Each intermediate cylinder will be so arranged as to exhaust either into the low-pressure cylinders or condensers, at will, as follows: A 20-inch pipe will lead from the exhaust side of each intermediate valve-chest, with a 20-inch branch to each end of the valve-chest of the corresponding low-pressure cylinder. This pipe will have a 20-inch straightway valve placed between the intermediate valve-chest and the branches to the

low-pressure valve-chest. There will be also a 16-inch pipe with a 16-inch straightway valve leading from the intermediate exhaust-pipe direct to condenser, as shown.

Each low-pressure cylinder will have a 28-inch exhaust-pipe leading to the condenser, with a straight-way valve.

All straight-way valves will be of composition and of approved pattern, each with a screw-stem and hand-wheel. They must be so fitted as to be held tightly to their seats when shut and easily moved when opening or shutting.

All these valves, when open, must leave an unobstructed passage for the steam. The valves will be so fitted as to be easily drawn from their chests.

WORKING-PLATFORMS.

The floors on the inboard side of each main engine, between the high and intermediate-pressure cylinders, will be conveniently arranged to serve as working-platforms. The counter, revolution-indicators, clock, gauges, telegraph-dials, and other engine-room fittings will be so placed near the working-platforms as to be in full view while working the engines. Speaking-tube mouth-pieces and telegraph-levers will be conveniently placed.

WORKING-LEVERS AND GEAR.

There will be at each working-platform the following hand-gear, viz:

One reversing-lever;
Three starting-valve levers;
Three cylinder drain-cock levers;
Hand reversing-pump lever;
Throttle-valve hand-wheel;
Steam throttle-valve lever;
Bleeder-valve hand-wheel;
Reversing-engine stop-valve hand-wheel;
Starting stop-valve hand-wheel.

All levers will have spring-latches of "locomotive pattern". The latches on reversing levers will be of May's pattern or equivalent.

SHAFTS.

All the crank, line, thrust, and propeller-shafts will be of steel. Each length will be forged solid in one piece, and will have a hole drilled axially through it from end to end.

All shafts will be finished all over.

CRANK-SHAFTS.

There will be three sections of crank-shafts for each propelling-engine, all alike and interchangeable. Each section will have a crank of 18 inches throw, and will have a coupling-disc 3¼ inches thick and 26 inches diameter forged on each end.

The length of each section of shaft will be 7 feet 9 inches over all. There will be two journals, one on each side of the crank, each 13 inches in diameter.

The shaft will be increased to 13½ inches diameter at the eccentric seatings. The crank-pins will be 14 inches diameter and 14 inches long. The crank-webs will each be 17½ inches wide and 9 inches thick; the webs to be rounded, as shown in drawing. The crank-pins must be accurately parallel to the main journals. All journals are to be smoothly and accurately turned, and when finished will be tested and their accuracy proved. There will be a hole 4 inches in diameter bored axially through each shaft and crank-pin. When bolted together the cranks will be at angles of 120° to each other; the intermediate to follow the high-pressure and the low-pressure to follow the intermediate.

The forward end of the hole in each crank-pin will be closed by a brass plate fastened on with countersunk screws.

Two radial ½-inch holes will be drilled in each crank-pin from the outside to the bore.

The various lengths of the crank-shafts will be coupled to each other by 3¼-inch bolts. There will be 6 bolts in each coupling, all holes being drilled or reamed to template, so that the couplings will match indiscriminately. The bolts will be made of forged steel, finished to fit the hole snugly, and each fitted with wrought-iron nut and split-pin.

Between the after coupling-disc of the crank-shaft and the forward disc of the thrust-shaft there will be a worm-wheel for turning the shaft. This wheel will be secured to the after disc of crank-shaft by six $3\frac{1}{4}$-inch bolts with cylindrical heads turned to a diameter of $4\frac{3}{4}$ inches, with hexagonal nuts, as shown. The thrust-shaft will be coupled to the crank-shaft by the cylindrical heads of these bolts passing through the discs on the forward ends of thrust-shaft with a neat working fit. There will be left between the faces of this wheel and the disc of thrust-shaft a space of $\frac{3}{8}$ inch.

THRUST-SHAFTS.

They will be $12\frac{3}{4}$ inches in diameter, with 6-inch axial holes. Each shaft will have eleven thrust-collars, $1\frac{5}{8}$ inches thick, with spaces of $2\frac{1}{8}$ inches, the collars to be $17\frac{1}{4}$ inches outside diameter. There will be a coupling-disc forged on the forward end $3\frac{1}{4}$ inches thick and $26\frac{3}{4}$ inches in diameter. The coupling-disc at the after end will be forged on and will be $3\frac{1}{4}$ inches thick and 26 inches in diameter, and the shaft will be increased in diameter for a short distance, so that the hole in the shaft can be counterbored to accommodate the nut on the central stud of the inboard propeller-shaft coupling.

PROPELLER-SHAFTS.

The propeller-shafts will each be in two lengths, $13\frac{1}{4}$ inches diameter. A $6\frac{1}{2}$-inch hole will be bored in the forward section of each shaft from the after end to within 16 inches from the forward end; thence it will be tapered to a diameter of 6 inches, $13\frac{3}{8}$ inches from end; it will be threaded and fitted with a steel stud, locked in place.

The forward section of each shaft will be about 21 feet $\frac{3}{8}$ inch long, cased with composition $\frac{3}{4}$ inch thick at the bearings and $\frac{3}{8}$ inch thick elsewhere. The casing will be shrunk and pinned on, and must be water-tight. The casings must be accurately and smoothly turned to form journals.

The forward end of forward section of shaft will be enlarged to a diameter of $14\frac{1}{2}$ inches for a length of $13\frac{3}{8}$ inches to receive a coupling sleeve. Beyond this, and for a length of 1 inch, the shaft will be $14\frac{3}{4}$ inches in diameter, to form a shoulder for the sleeve. This sleeve will be of cast-steel, 15 inches long, 27 inches outside diameter, and will be fitted and keyed by three feathers, each $2\frac{1}{4}$ inches wide and 2 inches thick. It will be secured to the shaft by a wrought-iron washer $15\frac{1}{2}$ inches in diameter and 2 inches thick; this washer being secured to the shaft by a central steel stud and nut to take up the backing thrust.

The stud will be fitted to a thread in the bore of the shaft and reduced to $4\frac{1}{2}$ inches diameter at the washer, its nut to be fitted with a suitable keeper. Six $3\frac{1}{4}$-inch steel bolts will unite this sleeve to the after coupling of the thrust-shaft. The coupling-bolts will be fitted snugly in the sleeve for 3 inches from the face, the remainder of the bolts being turned to clear.

The after end of forward section will have a coupling-disc forged on, $25\frac{3}{4}$ inches diameter, $3\frac{1}{2}$ inches thick.

The after section will be about 26 feet $10\frac{1}{2}$ inches long, cased with composition $\frac{3}{4}$ inch thick where it passes through the stern-tube up to the outboard-coupling, as shown. It will have forged on the forward end a coupling-disc of $25\frac{3}{4}$ inches diameter, $3\frac{1}{2}$ inches thick.

The after end will be tapered to fit the bore of the propeller-boss, and will be fitted for two feather-keys.

Abaft this the diameter will be reduced to $9\frac{1}{2}$ inches, threaded and fitted with a nut and keeper, the thread being turned off abaft the nut. There will be a water-tight plug in the after end.

The hole in this section of the shaft will be $6\frac{1}{2}$ inches diameter, except in that part passing through the propeller-hub, where it will be tapered so as not to reduce the thickness of the metal around the hole.

The two lengths of each propeller-shaft will be coupled to each other by six 3¼-inch bolts, with heads and nuts made perfectly water-tight when set up. The bolts will be fitted with nuts locked in place.

There will be at the forward end of the after section of each propeller-shaft a cast-steel casing to form a fair water-line from the end of the stern-tube to the shaft, as shown in drawings. The casing will be finished on the outside and bored to fit the shaft and couplings. It will be secured to the coupling by six ¾-inch square-headed countersunk iron screws, as shown, tapped into the coupling-disc.

The shaft, couplings, and casings will be well coated with the same composition as the hull.

LUBRICATION.

All working parts of the machinery will be fitted with efficient lubricators, each with a sufficient oil capacity for four hours' running. Each main crank-pin will have a centrifugal oiling device on the after face of the crank, made of composition and fastened to the crank by countersunk screws. Each centrifugal oiler will be fed by a pipe leading from a fixed sight-feed cup in an accessible position. Each main crank-pin will also be oiled by cups carried on the cross-head, taking oil from wicks overhead; the oil to be carried to the crank-pins by brass pipes secured to the connecting-rods. These pipes will have union joints where connected to oil-cups.

There will be a small oil-tank, with glass gauge, placed in a convenient position and connected by pipes with a closed oil-box at each crank-shaft bearing, so that when necessary oil can be supplied to the journals under a head. From each of these boxes four tubes will lead to the bearing, each with valve adjustment, and with a sight-feed with a well-protected glass tube.

Each main cross-head journal will take oil from an overhead wick-cup.

Each cross-head guide will be oiled by pipes leading to about the middle of each forward and each backing-guide.

There will be a globe oil-cup for each piston-rod, and one for each end of each valve-stem; also one for each piston-valve. These will be placed sufficiently high to insure the oil running where desired without regard to the trim of the vessel.

Each valve-link will carry a divided oil-cup, one division for the upper and one for the lower connection, with proper channels; these cups to take oil from fixed cups overhead.

Each equalizing-bar will carry two oil-cups, one for oiling the link-block pin and the other for oiling the pin on rock-shaft arm. These cups to take oil from fixed cups overhead. Each end of each radius-link will carry a broad oil-cup fed by a drip-pipe from an overhead fixed cup.

The valve-motion rock-shaft bearings will each be lubricated through a pipe leading from an oil-box on the cylinder-casing.

Each eccentric will have a long oil-cup fed by a drip-pipe, so arranged that the eccentric will be lubricated in all positions. The upper end of each eccentric-rod will carry a wiper oil-cup on each fork, these cups to take oil from wicks in cups easily adjusted to the various positions of the gear. The coupling between the after section of crank-shaft and thrust-shaft will be fitted with a centrifugal oiling apparatus with a pipe leading to each bolt-head in the thrust-shaft coupling-disc.

There will be fitted to each main steam-pipe, close to valve-chest, a Detroit or equivalent steam sight-feed oil-cup of two quarts capacity, with gauge-glass. As far as possible all the oil for the moving parts of each engine, except main bearings, will be supplied from one oil-box on the cylinder, with separate valve, sight-feed, and pipe for each part to be oiled. There will be steam sight-feed cups on each circulating, blowing, main-feed, air-pump, and bilge-pump engine. All steam sight-feed cups will have ample condensing surface on their

steam-pipes. Each three-cylinder engine will have a continuous automatic lubricator of approved pattern. All working parts for which oil-cups are not specified or shown in drawings will have oiling-gear of approved design, such that they can be oiled without slowing. All the oiling of each auxiliary engine will be done by one oil-box where practicable. All fixed oil-cups will have hinged covers, with stops to prevent being opened too far. Moving oil-cups, where necessary, will have removable covers. The supply of oil to various parts is to be easily regulated. All oil-cups and their fittings, except such as are cast on bearings, will be of finished cast brass, or of sheet brass or copper, as may be directed, with all seams brazed.

OIL-DRIPS.

All fixed bearings will have drip-cups cast on where possible, otherwise they will be of cast-brass, properly applied. All moving parts will have drip-cups or pans cast on engine-frames where directed, otherwise to be substantially made of sheet-brass, or copper with brazed seams. All drip-cups will have drain-pipes and cocks of at least $\frac{1}{2}$ inch diameter, which can be used while the engines are in operation.

JOURNAL-BOXES.

All journals or moving parts of iron or steel will run, unless otherwise specified, in composition boxes. These boxes will be lined with approved anti-friction metal where directed. All adjustable bearings will be provided with channeled-brass chipping-pieces, securely held in place and easily removable.

MANDRELS FOR WHITE-METAL BEARINGS.

Hollow cast-iron mandrels will be furnished for forming the white-metal linings of crank-pin, crank-shaft, line-shaft, and thrust-bearings. All these will be smoothly and accurately turned to size and packed so as to be perfectly protected.

STUFFING-BOXES.

All iron boxes will be bushed with composition. All glands will be of composition and fitted with approved means of adjustment while the engines are in operation, and those not fitted with pinion-nuts and spur-rings will have lock-nuts and split-pins. Metallic packing of approved kind, and equal in all respects to Watson's, will be fitted in stuffing-boxes of all piston-rods and valve-stems of main and auxiliary engines over $1\frac{3}{4}$ inches diameter. Stuffing-boxes of piston-rods and valve-stems between $\frac{3}{4}$ and $1\frac{3}{4}$ inches diameter will be fitted with metallic packing of Katzenstein's pattern, or equivalent.

BOLTS AND NUTS.

All bolt-heads and nuts less than 2 inches, except in special cases, will conform to the United States Navy standard. Screw-threads on bolts and nuts must in all cases conform to the above standard. All finished bolts, except as directed, will be kept from turning by dowels or other suitable devices.

The nuts of all bolts on moving parts and on pillow-blocks, and elsewhere as shown, will be fitted with keepers, and the bolts will extend beyond the nuts, without threads, and fitted with split-pins.

THRUST-BEARINGS.

Each thrust-bearing pedestal, of cast-iron, will be bored out to receive the lower part of bearing, and firmly bolted to the seating provided. The bearing will be in two parts, of cast-iron, with white-metal linings. The lower part will be turned to fit the pedestal. The upper part, or cap, will be separated from the bottom by composition distance-pieces, and will be fitted in place with ten $1\frac{1}{4}$-inch wrought-iron dowel-pins, fitting snugly in holes in the lower part of bearing. The cap will be faced to fit longitudinal recesses in the upper flanges of pedestal, and will be held down by eight $1\frac{1}{2}$-inch wrought-iron bolts, body-bound in pedestal, but with slotted holes in cap. Each cap will have a box cast on top, with a hinged cover.

The end and side walls of the pedestal will form an oil-trough, from which there will lead an oil-hole to each collar and each recess, the white metal being properly channeled for distribution of oil. Inside this trough, both forward and abaft the thrust-collars, will be a composition bearing about 8 inches long for taking the weight of the shaft. The cap for this bearing will be of cast-iron lined with white metal. These bearings will be adjustable vertically by wedges with regulating-screws.

At each end of each thrust-bearing there will be a divided stuffing-box and gland to prevent escape of oil. At the bottom of each thrust-bearing there will be a fore-and-aft channel connecting all the bearing recesses; a drain-cock to be fitted at each end.

The oil-trough will also be fitted with a cooling coil as shown in drawings. There will be four adjusting-screws, of 3 inches diameter—two at each end of the thrust-bearing pedestal for adjusting the bearing fore and aft. The caps will be fitted with eye-bolts for convenience of handling.

JACKS FOR COUPLING-BOLTS.

A hydraulic jack of approved pattern will be fitted for withdrawing the bolts of the shaft-couplings.

STERN-TUBE BEARINGS.

Each stern-tube will be finished as follows: A composition lining, turned to fit the stern-tube, will be inserted from the outer end, and will be secured by a water-tight flange-joint. This lining will be about 19$\frac{5}{8}$ inches outside diameter at the outboard end and 19$\frac{1}{4}$ inches outside diameter at the inboard end, varying between these dimensions $\frac{1}{8}$ of an inch at each bearing in the stern-tube, to permit the lining to be entered and withdrawn readily. The inside diameter of lining will be 17$\frac{3}{4}$ inches. The full length of the lining from the face of the inboard flange, which will be screwed on, to the after end of the lining, will be about 16 feet 4$\frac{1}{4}$ inches.

Fitted to the composition lining at each end will be a composition bushing, made in halves, the joint to be in a horizontal plane when bushing is in place. These bushings will be 31 inches long at the inboard end and 32 inches long at the outboard end, and fitted with sections of lignum vitæ, put in so as to wear on end of grain, and smoothly and accurately bored in place to suit the shaft-casing. They will be held in place in the inboard bushing by a flange at its outer end and stuffing-box flange at the inner end; and in the outboard bushing by a flange at inner end of bushing and a composition ring, made in halves, secured to the bushing-flange by naval-brass tap-bolts at outward end. All the lignum vitæ bearings will be well water-soaked and bored out in place to perfect alignment and to a loose fit on the shaft-casing. The inboard bushing will be so fitted that, after the stuffing-box is taken off, the bushing can be removed while the shaft remains in place.

STERN-TUBE STUFFING-BOXES.

At the forward end of each stern-tube there will be a composition stuffing-box, made in halves, divided longitudinally. It will be bolted to the flange on the forward end of the stern-tube bushing. The two parts will be bolted together along the longitudinal division by proper flanges. The follower will be of composition, in two parts, with a space of 1¼ inches between the parts on each side. The packing spaces will be about 7 inches deep and 1 inch wide.

The follower-bolts will be of naval brass. To each stuffing-box, abaft the packing, a 1½-inch pipe will be attached, leading to the engine-room bilge. It will also be connected with the engine-room water-service pipes, and will be provided with valves, so that the bearing can be drained into the bilge, or washed out by water from the engine-room pump at will.

STERN-BRACKET BEARINGS.

Each stern-bracket bearing will have a neatly fitting composition lining, made in halves, divided longitudinally, about

1¾ inches thick at ends and 1 inch thick in the middle. It will have a flange 1¾ inches thick, by which it will be secured to the forward end of the stern-bracket. It will have a lignum vitæ bearing about 4 feet long, fitted as in the stern-tube. The lignum vitæ will be held in place at the after end by a flat ring bolted to the lining. A cast-steel sleeve, ½ inch thick, will be secured to each stern-bracket by six ¾-inch screws, to form a fair water-line to the propeller-boss. At the forward end of each bearing there will be a composition sleeve, ½ inch thick, secured to and supported by an extension of the lining before mentioned. This sleeve will be shaped to form a fair water-line from the shaft to the stern-bracket boss, and will be finished on the outside.

SCREW-PROPELLERS.

They will be of manganese or aluminum-bronze. The starboard propeller will be right and the port one left-handed. They will be three-bladed, about 15 feet in diameter. Each blade will be firmly bolted to the boss by tap-bolts of naval brass, secured by lock-plates. The recesses for the bolt-heads will be covered by composition plates held by countersunk screws, and finished to form a smooth surface fair with the boss. The details of the blades will conform to such drawings as may be hereafter furnished.

Each boss will be accurately bored to fit the taper on after end of shaft and fitted with two feather-keys. Each propeller will be held on the shaft by a nut screwed on and locked in place. The shaft-casing will enter about 1 inch into the propeller-boss and be fitted water-tight. Each boss will be finished at the after end by a composition cap bolted on water-tight. The bosses and caps will be finished all over. The blades will be cast as smoothly as possible and have any roughness removed. The flanges of the blades will be turned and faced to fit the recesses in the bosses accurately, and, after being secured in place, must have the edges made fair.

CONDENSERS.

The condensers will be cylindrical, 6 feet 5½ inches internal diameter, each made in three principal sections; the middle section of composition and the others of composition or sheet-brass not over ¼ inch thick.

There will be the following openings in the middle section of each condenser, each with properly faced flanges, viz:

One for main exhaust-pipe, 28 inches diameter;

One for intermediate exhaust-pipe, 16 inches diameter;

One for auxiliary exhaust-pipe, 6 inches diameter: this nozzle to have branches for the air and circulating-pump engine exhaust-pipes, also a branch nozzle for the auxiliary xhaust-pipe;

Two for air-pump suction-pipes, 7½ inches diameter;

One for salt-feed pipe, 2 inches diameter, with a spray in the exhaust passage;

One for steam-pipe for boiling the water in condenser;

One 15 x 12 inch man-hole at the side of the main-exhaust nozzle;

One 15 x 12 inch man-hole at the bottom.

Each condenser will have a bracket at each end to secure it to the engine-room bulkhead, and one supporting bracket at each end; each of these brackets being secured to extensions of the tube-sheet. The condenser will be supported at one end by the air-pump and at the other by the feed-tank. The supporting brackets will be of plate iron, stiffened by angles.

The condenser-tube sheets will be made of composition, 1 inch thick, with smoothly finished holes for the tubes, tapped and fitted with screw-glands for packing the tubes. The glands will be beaded at outer ends to prevent tubes from crawling, and will be slotted to admit a tool for screwing up. Cotton-tape packing will be used. There will be 5,140 seamless-drawn brass tubes in each condenser, ⅝ inch outside diameter, No. 20 B. W. G. in thickness. The tubes will be 8 feet 4 inches long between tube-sheets and will be spaced $1\frac{5}{16}$ inch between

main exhaust-nozzle, above the tubes, will be a deflecting-plate, supported as shown.

A 2-inch salt-feed pipe, with a spray in the exhaust-passage, will be fitted to each condenser. A copper tank, pipe, and cock will be provided for admitting an alkaline solution into the condenser—this pipe to connect with the salt-feed spray; the tank to be of at least 10 gallons capacity and conveniently placed. A 1½-inch branch from the auxiliary steam-pipe will lead to the bottom of the condenser for cleaning the tubes by boiling.

Drain-cocks will be provided, with pipes leading to the bilge.

All parts of the condensers, except as otherwise specified, will be made of composition. All bolts to be made of naval brass. All bolts for securing flanges of pipes and man-hole plates will be standing bolts, and will, wherever possible, be screwed into the condenser-plates with heads inside. The condensers must be perfectly tight all over and be so proved after being secured in place.

AIR-PUMPS.

There will be a double double-acting horizontal air-pump, driven by a two-cylinder vertical inverted cylinder compound engine, for each propelling engine. The engine will drive a crank-shaft, carried in four bearings, with cranks at right-angles and with a fly-wheel at each end. The air-pump connecting-rods will be connected to the same crank-pins as the engine connecting-rods—the former having forked ends and the latter single ends.

All parts of the pumps, except as otherwise specified, will be made of composition. Each air-pump will have a piston working in a cylinder of 17½ inches bore. The stroke will be 18 inches. The pump-pistons will be cast hollow, and must be tested for perfect tightness. Each piston will have a wearing surface of lignum vitæ, as shown, bearing on end of

grain. The piston packing will be made of hemp, set up by a follower with locked nuts. The pump piston-rods and follower-bolts will be made of rolled phosphor-bronze or aluminum-bronze. There will be twelve foot-valves and twelve delivery-valves at each end of each pump, all 4 inches in diameter, made of the best hard rubber or of such other material as may be approved. Each valve will be held in place by a guard and a spiral spring of phosphor-bronze or aluminum-bronze. The valves and guards must be easily removable, and held firmly in place. The valve-seats will be made separately from the pump-casings and will be bolted in place. The foot-valve seats will be placed in inclined positions at the sides of the pumps, and the delivery-valves horizontally at the highest parts of the pump-chambers. There must be no pockets in the pump-chambers, underneath the delivery-valves, where vapor can lodge. The gratings of the valve-seats must be so arranged that the clear opening of each valve shall be at least 6¼ square inches. The pump-barrels will be provided with working linings. The pump-casings and bonnets will be well ribbed. The bonnets will be provided with jack-bolts and eye-bolts. Each air-pump will have two suction-nozzles, each 7½ inches in diameter. Each of these nozzles will be connected by a copper pipe and straightway-valve to the corresponding nozzle on the bottom of the condenser.

Each hot-well will be formed to act as an air-chamber. Each air-pump will have two outlets, each 5 inches in diameter, connected by a copper pipe, a prolongation of which will lead to the feed-tank. The top of air-chamber will have flanges as shown for one of the supporting brackets of the corresponding condenser.

The engine-cylinders will be 10⅜ and 16½ inches bore respectively. Each cylinder will be supported at the back by a cast-iron frame forming the cross-head guide, and at the front by a wrought-iron column. The cylinders and bed-plates will be bolted together as shown. The high-pressure

and low-pressure valve-chests of each engine will be connected by a copper pipe 3 inches diameter. The pistons and cylinder-covers will be made of cast-steel. The crank-shafts, piston-rods, and connecting-rods will be made of forged steel. The pistons will be fitted with cast-iron packing-rings. The cross-heads will have cast-steel slippers, lined with white metal, working in cast-iron guides with composition guards. The crank-shafts will be $3\frac{3}{4}$ inches diameter, with bearings $4\frac{1}{2}$ inches long. Each crank-pin will be 4 inches diameter and $6\frac{1}{2}$ inches long. Each cylinder will have a slide-valve, worked through gear, as shown, by a pin carried on a plate so secured to the fly-wheel that its position may be varied.

Each engine will take steam from a branch of the main steam-pipe, with a stop-valve having a hand-wheel at the working-platform, and will exhaust by a special pipe into the condenser.

The air-pump engines will be connected to the pumps by cast-iron frames, which will form the air-pump cross-head guides. The engines, pumps, and frames will be securely bolted to the seatings provided for them.

Each air-pump, together with its condenser, must maintain a vacuum of within four inches of mercury of the atmospheric barometer with the propelling-engines at full power under forced draught.

CIRCULATING-PUMPS.

There will be a centrifugal circulating-pump for each condenser, driven by an inclosed three-cylinder engine. Each pump must be capable of discharging 8,000 gallons of water per minute from the bilge. The pumps will be made of composition, except as otherwise specified. Each pump-casing will be made in two parts, divided in a horizontal plane, the upper part with conveniences for handling. The suction-nozzle will form a support for the pump and will be securely bolted to its seating. This nozzle will have an opening for sea suction not less than 15 inches diameter, and a 15-inch opening for bilge

suction. The pump-runners will be 42 inches in diameter, smoothly cored, finished on the outside, and perfectly balanced. The shafts will be of phosphor-bronze or aluminum-bronze. The bearings will consist of sections of lignum vitæ on end of grain, dovetailed into composition split-sleeves, which will be well secured against turning. The stuffing-box glands will be each in two parts. There will be an air-cock at the top of the pump-casing and a drain-cock at the bottom. The pump-casings must be made as light as possible consistent with strength, and must be smoothly cored, with easy bends wherever the direction of the flow of water is changed.

CIRCULATING-PUMP ENGINES.

They will be of the inclosed three-cylinder single-acting type, of approved pattern; each of sufficient power to secure the results above specified. The engine-valves must be of either the slide or piston type.

CIRCULATING-PUMP CONNECTIONS.

Each circulating-pump will be fitted with pipes and valves to draw from the sea or engine-room bilge, and will deliver into the condenser; or direct to the outboard-delivery pipe by a pipe connecting inlet and outlet of condenser. This pipe and the inlet-pipe to condenser each to have a damper-valve of approved pattern.

The injection and delivery-pipes for condenser circulation will be not less than 15 inches internal diameter.

There will be damper-valves in the pipes leading from the sea and from the bilge to the circulating pump in each engine compartment. These valves will be so connected by levers that when one is shut the other is open; and both will be worked by a lever well above the floor-plates.

SEA-INJECTION VALVES.

There will be a straightway screw main injection-valve of not less than 15 inches diameter in each engine compartment. It will connect with the sea by a conical steel tube through the double-bottom.

There will be a strainer on each pipe at the ship's side. The hand-wheels of these valves must be easily accessible above the engine-room floor-plates.

There will be a 1½-inch steam-pipe leading from the auxiliary steam-pipe to the injection-pipe outside of injection-valve. This pipe to have a valve at each end.

BILGE-INJECTION VALVES.

They will be as specified under the head of "Bilge-Suction Pipes".

OUTBOARD-DELIVERY VALVES.

There will be in each engine compartment a main outboard-delivery valve of the same size and type as main injection-valves.

The valve in each compartment will connect with a steel pipe about ⅝ inch thick passing through the double-bottom. The hand-wheels will be accessible from the engine-room.

FEED-TANKS.

There will be a feed-tank under each condenser, placed as shown in the drawing. Each tank will have a capacity of about 65 cubic feet. It will be made of ¼-inch wrought-iron, utilizing the supporting brackets of the condenser for a portion of one side. It will be stayed internally as may be directed. Each tank will have at least 75 cubic inches of rolled zinc plates, about ½ inch thick, suspended from the braces. The straps suspending the zinc plates and the braces where the straps come in contact will be filed bright before fitting. The parts to be then well painted on the outside, or the joints to be made water-tight in other approved manner. The upper portion of the tank will be fitted as a filter, into which the water from the air-pump will be delivered. The filter will be provided with sponges, and so arranged that the sponges will be readily accessible. Each tank will have a man-hole with bolted cover, and will have a glass water-gauge with suitable guards, shut-off cocks, and drain-cocks.

Each tank and filter will have the following pipe connections: A discharge-pipe from each air-pump; an overflow-pipe leading to bilge, but so arranged that any water passing down it may be seen; a suction-pipe to feed-pumps, with valve; drain-pipes from traps, as elsewhere specified; a vapor-pipe, 4¼ inches diameter, of copper, No. 16 B. W. G. The vapor-pipe will lead up the engine-room hatch and discharge above the level of the awnings, where it will have a suitable hood, or it may be led into the main escape-pipe. Each feed-pump suction will be provided with a balanced-valve operated by a copper-float in the feed-tank, so arranged that it will allow no air to enter the feed-pipes. All trap discharges and drains will enter the feed-tanks well below the ordinary water level.

FEED-TANK SUCTION-PIPES.

From the port feed-tank, a 4-inch suction-pipe will lead to the main and auxiliary feed-pumps in the forward fire-room, and from the starboard tank, a similar pipe to the after fire-room. These pipes will be connected with each other in the engine-rooms with valves, so that either feed-pump can draw from either or both tanks. Non-return valves will be fitted in these pipes close to auxiliary feed-pumps.

SUCTION-PIPES FROM BOTTOMS OF CONDENSERS.

From each air-pump channel-way below the foot-valves a 2-inch pipe will lead to the corresponding feed-tank suction-pipe, with a screw-down non-return valve.

SEA-SUCTION PIPES.

A pipe will lead from the sea-suction valve in each engine-room to the fire and bilge-pump, and to the auxiliary-pump in its compartment. In each boiler compartment pipes will lead from the sea-suction valve to the auxiliary feed-pumps. A pipe will also lead from a special sea-valve, fitted where directed, to the distiller circulating-pump. Each of these pipes will be of at least the same bore as the nozzle on the pump with which it connects. Each sea-suction will be con-

trolled by a valve which will not permit sea-water to enter any of the bilge-suction pipes or feed-tank suction-pipes.

There will be the following suction-pipes from the bilge and from the drainage-pipes to the various pumps:

A 15-inch copper pipe will lead inboard from each circulating-pump, with a damper-valve close to the pump, as before specified. A 12-inch branch from each of these pipes will lead into the main drainage-cistern in the starboard engine-room, with a screw-down non-return valve which can be lifted from its seat by means of its stem. Each pipe will also have a 12-inch branch direct to the bilge in its own compartment, with a non-return valve which can be lifted from its seat by means of a sliding stem, but without means of fastening it shut except by lashing the lever by which its stem is worked. The above-mentioned suction-pipes will not have strainers.

A 3-inch pipe will lead from the lowest part of the bilge of the compartment abaft the engine-rooms to both of the fire and bilge-pumps. A pipe of the size of the secondary drain-pipe will lead from that pipe to both fire and bilge-pumps. A pipe of the full size of the combined fire and bilge-pump suctions will lead out of the main drainage-cistern and will branch into two pipes, each of the size of one pump-suction, and lead to these pumps. The three pipes here specified, which supply each fire and bilge-pump, will lead to a valve-box near the pump, which will contain a screw-down non-return valve for each suction. Between this valve-box and the pump there will be a Macomb, or equivalent, bilge-strainer. There will be no other strainer or valves in any of these pipes other than these herein specified.

Each auxiliary feed-pump will have a suction-pipe of the full size of its suction-nozzle leading into fire-room drainage cistern in the after end of each boiler compartment. Each pump will also have a 2-inch suction from the main air-duct. In addition to these the forward auxiliary feed-pump will

have a 3-inch suction from the lowest part of the bilge of the first compartment forward of the double-bottom. The suctions to each pump will lead to a valve-box and strainer, fitted as before specified, for the suctions to the fire and bilge-pumps.

The lower ends of all bilge-suction pipes will be of galvanized iron. Care will be taken that all the copper bilge-pipes are led sufficiently high to keep them out of the bilge water under ordinary circumstances.

FIRE AND BILGE-PUMPS.

There will be in each engine-room a pump of approved design, which will be used as a fire and bilge-pump. It will have a capacity of 300 gallons per minute, with steam cylinder of suitable size to work as a fire-pump with steam of 60 lbs. pressure. Each of these pumps will have suctions from the sea, the bilge of the compartment next abaft the engine-rooms, the secondary drain-pipe, and the drainage cistern; and will deliver into the fire-main and overboard.

ENGINE-ROOM AUXILIARY-PUMPS.

There will be in each engine-room an auxiliary-pump of approved pattern, of 150 gallons capacity per minute, and with cylinders of proper proportion to be used as a fire-pump, with steam of 60 lbs. pressure. This pump will have suction from the sea only, and will deliver into the engine-room water-service pipes and the fire-main only.

ENGINE-ROOM WATER SERVICE.

There will be in each engine-room a 3-inch pipe connected with a special sea-valve and with a special auxiliary-pump delivery, with branches leading to the different parts of the engine, as follows:

A 1½-inch branch connected by a union-joint with a pipe screwed into the cap of each crank-shaft bearing, and leading through brasses to top of journal;

Two 1½-inch pipes to each crank-pin;

Two 1-inch pipes to each cross-head;
One 1¼-inch pipe to each cross-head guide;
One 1-inch pipe to each pair of eccentrics;
One 2-inch pipe to each thrust-bearing;
One 1-inch pipe to each line-shaft bearing;
Two 1-inch pipes to each air-pump engine and to each circulating-pump engine.

All of the above to have detachable sprays or short lengths of hose, as directed, and where directed to have pivoted nozzles.

Each branch will have a separate valve.

All the water-service pipes and fittings above the floors will be of polished brass. The pipes in the two engine-rooms will be connected with each other by a 2-inch pipe and valve.

TURNING-ENGINES AND GEAR.

There will be in each engine-room a double engine of suitable size for turning the main engines with steam of 60 lbs. pressure. This engine will drive by worm gearing a second worm, which may be made at will to mesh with a worm-wheel on the propelling-shaft. The worm-wheel of each engine will be fitted on the flange-coupling at after end of crank-shaft.

The turning-engine shaft will be squared at the end and fitted with a ratchet-wrench, of approved design, for turning by hand.

Each turning-engine will have piston-valves, and will be made reversible by means of a change-valve moved by a screw and hand-wheel.

The turning-wheels will be of cast-steel with cut teeth.

SECURING ENGINES IN VESSEL.

The engines will be adjusted and aligned upon the engine-keelsons, and when accurately in line snugly-fitting wrought-iron washers will be fitted around all holding-down bolts. The holding-down bolts will be firmly set up and bolts and nuts locked in place.

When finally secured all shafting must be accurately in line with the vessel at load-draught and ordinary stowage.

All parts of machinery and boilers will be secured in an approved manner to prevent displacement when the vessel is used for ramming.

The seatings for engines, boilers, and auxiliaries will be furnished by the Navy Department, but will be fitted to the machinery by the contractor for the machinery.

STEAM AND VACUUM-GAUGES.

There will be the following gauges, in polished brass cases, suitably engraved to show to what they are connected; all to be of approved pattern and equal to "Lane's improved":

Two on each boiler;

One connected to each main steam-pipe;

One connected to each intermediate valve-chest;

One connected to each low-pressure valve-chest;

One connected to each condenser.

All the above will have 8½-inch dials; those in engine-room to be at the working-platform.

Also the following with 4½-inch dials:

One connected to each intermediate cylinder-jacket;

One connected to each low-pressure cylinder-jacket;

One on auxiliary steam-pipe in each engine-room and each fire-room.

The gauges on valve-chests and steam-jackets will be plainly marked with the limit of pressure permissible. The gauges on intermediate and low-pressure valve-chests will indicate both pressure and vacuum.

A mercurial vacuum-gauge will be connected to each condenser.

In addition to the above there will be a 4½-inch steam-gauge at the windlass, one at the steering-engine, one at each hydraulic pumping-engine, one on each hydraulic main, and such as are elsewhere specified.

THERMOMETERS.

There will be the following thermometers—all to be permanent fixtures, with their stems and bulbs protected by

brass covers; the casings and fittings to be of polished brass:

One on each hot-well;
One on each feed-tank;
One on each main feed-pipe in fire-rooms;
One on each main injection-pipe;
One on each main outboard-delivery pipe;
One on each main steam-pipe close to engine.

The hot-well and feed thermometers will be so fitted as to waste no feed-water.

There will also be furnished:

Four spare water-thermometers complete;
Six spare steam-thermometers complete;

Two standardized thermometers, graduated on stem and reading to $\frac{1}{10}$ degree Fahrenheit; stems to be at least 20 inches long; each thermometer to be in a rubber-lined brass case, and each case to be suspended by springs in a suitable permanent locked case in engine-room. These thermometers must be equal to those made by H. J. Green, and be accompanied by certificates of standardization.

REVOLUTION-COUNTERS.

They will be of the continuous rotary type, to register from 1 to 1,000,000, each worked by positive motion; each to be in a polished brass case. There will be fitted:

One for each main engine;
One for each air-pump;
One for each circulating-pump.

REVOLUTION-INDICATORS.

They will be of such approved pattern as shall not be affected to a perceptible degree by the motion of the ship or by changes of temperature. They must be worked off the engines by positive motions, and must be so fitted that changes of engine speed shall not produce violent fluctuations of the indices. There will be two in each engine-room, one to show the speed of each propeller.

Tell-tales will be fitted on the bridge and in the conning-tower, to show the direction of revolution of the main engines.

ENGINE-ROOM TELEGRAPHS.

A repeating-telegraph of approved pattern will be fitted in each engine-room with its dial at the working-platform, and connected to transmitters in conning-tower, in wheel-house, and on bridge. The connections are to be made in such manner that the chance of derangement shall be minimized.

SPEAKING-TUBES.

They will be made of copper not less than No. 20 B. W. G. They will connect each engine-room with each fire-room; the engine-rooms with each other; the fire-rooms with each other; each engine-room to the pilot-house, conning-tower, bridge, and to the chief engineer's room; each fire-room with the upper deck close to the top of the ash-hoist, and elsewhere as required. Each tube will be fitted at each end with a mouth-piece and approved annunciator; the mouth-pieces to be connected to short flexible pipes where required. All mouth-pieces or pipes will be plainly marked. The tubes will be suitably cased where necessary.

ENGINE-INDICATORS.

An indicator connection will be made to each end of each cylinder of main engines, and to each end of each steam and water-cylinder of each air-pump, as near as possible to the bore of the cylinder, and so as to be easily accessible. Each indicator on cylinders of main engines, when in place, will be connected to but one end of a cylinder. The connecting-pipes will be 1-inch bore, without bends. The indicator-motion of each engine and air-pump will be so fitted that both indicators on its cylinder can be connected at the same time. The motions of the indicator-barrels must be accurately coincident with the motion of the corresponding pistons, and such as to give a motion of not less than 4 inches. The steam-cylinders of

all auxiliary engines will have holes tapped for indicator-fittings, and then plugged. These engines will have portable indicator-motions fitted, then removed and suitably marked and stowed. Where auxiliary engines are duplicated but one set of indicator-motion fittings need be supplied for all of each kind.

Eight indicators will be furnished for each engine-room: two for the high-pressure cylinder, each with a spring of 80 pounds to the inch, and one of 64 pounds; two for the intermediate cylinder, each with a spring of 40 pounds to the inch, and one of 32 pounds; two for the low-pressure cylinder, each with a spring of 20 pounds to the inch, and one of 16 pounds; and two indicators for auxiliary engines, each with springs of 10, 20, 40, and 80 pounds to the inch.

The indicators will be of approved type, with detent-motion and with adjustable tension to the barrel-spring. They will be nickel-plated, and will be complete with all attachments. One extra cock-attachment will be furnished with each indicator. Each indicator will be in a separate locked case; each case to be suitably marked on a brass plate, and each case to be conveniently stowed.

ENGINE-ROOM DESKS.

A black-walnut desk of approved pattern, with locked drawers, and with a locked cabinet of pigeon-holes, will be fitted in each engine-room where directed.

CLOCKS.

There will be in each engine-room, close to the counter, an eight-day clock of approved pattern, with second-hand, in a polished brass case, with 8½-inch dial.

There will be in each fire-room a similar clock, with an outer dust-tight case with heavy plate-glass.

VENTILATING FANS.

An exhausting fan with a capacity of at least 10,000 cubic feet of air per minute will be fitted in each engine-room.

Air-ducts will be led to these fans with adjustable openings so arranged as to throughly ventilate the engine-rooms and shaft-alleys; the air to be discharged through ducts leading up the engine-room hatch with outlets so arranged that the foul air will not be drawn back down the hatch.

Each fan will be driven by an independent engine of the same kind as specified for the fire-room blowers.

BOILERS.

There will be eight cylindrical, single-ended, horizontal return-tube boilers, 14 feet 8 inches greatest diameter and 10 feet long. Each boiler will have three corrugated furnaces 42 inches in least diameter. The total grate-surface will be 553 and the total heating-surface about 18,800 square feet. The boilers will be divided into two groups, each in a separate water-tight compartment, with a central fore-and-aft fire-room.

BOILER MATERIAL.

All plates used in the construction of the boilers will be open-hearth steel. The rivets will be of open-hearth or Clapp-Griffith's steel. The tubes will be of steel equal to that used by the Tyler Tube Co. All material will be tested as elsewhere specified.

BOILER-SHELLS.

They will be made of $1\frac{1}{32}$-inch plates—the shell of each boiler to be made in two rings; each ring of three plates.

BOILER-HEADS.

Each head of each boiler will be made of three plates: the upper plate of each head $1\frac{1}{32}$ inch thick; the middle plate of the front head $\frac{3}{4}$ inch thick; the middle plate of back head and the lower plates of both heads $\frac{11}{16}$ inch thick. The heads will be flanged outwardly at the furnaces and inwardly at circumference. The upper plate of each head will be curved back to a radius of about 2 feet 8 inches to meet the shell of boiler. The heads will be stiffened by vertical T-bars, as shown in drawings.

BOILER-TUBE SHEETS.

They will be $\frac{3}{4}$ inch thick. Each pair of tube-sheets must be accurately parallel. All tube-holes will be slightly rounded at the edges. The holes for stay-tubes will be tapped in place. The holes at combustion-chamber end will be drilled to suit the protection of tubes, as specified below.

BOILER-TUBES.

They will be of steel, lap-welded, equal in all respects to Tyler's. There will be 118 stay-tubes and 401 ordinary tubes in each boiler, 6 feet 7 inches long between tube-sheets. All tubes will be $2\frac{1}{4}$ inches external diameter. The ordinary tubes will be No. 12 B. W. G. in thickness, and will be swelled to $2\frac{5}{16}$ inches external diameter at the front ends. The back ends will be expanded into recesses in the tube-sheet, or will be protected from the action of the flame in other approved manner. The method of protection must be such as will not interfere with the use of ferrules, and will not cause injury to the tube-sheet when tubes are cut out.

The stay-tubes will be No. 6 B. W. G. in thickness. They will be reinforced at both ends to an external diameter of $2\frac{3}{8}$ inches, leaving the bore of the tube uniform from end to end. They will then be swelled at the front end to $2\frac{1}{2}$ inches external diameter. They will be threaded parallel at combustion-chamber ends, and taper at front ends to fit threads in tube-sheets. They will be screwed into the tube-sheets to a tight joint at the front end, and will be made tight at the back ends by expanding and beading. All expanding will be done by approved tools. All tubes will be spaced $3\frac{1}{4}$ inches from center to center vertically and $3\frac{1}{2}$ inches horizontally.

COMBUSTION-CHAMBERS.

There will be three combustion-chambers in each boiler, one for each furnace. They will be made of $\frac{1}{2}$-inch plates except the tube-sheets, which will be as before specified. The

backs of the combustion-chambers will be rounded at the top to a radius of about 2 feet 4 inches, as shown in the drawing. The plates will be flanged where necessary, and all parts joined by single-riveting. The holes for screw stay-bolts in plates of combustion-chambers and shells will be drilled and tapped together in place.

BOILER BRACING.

The bracing of each boiler will be as follows:

Twenty 2-inch through braces in two horizontal rows, spaced 14 inches center to center horizontally and vertically. The upper row will be just below the beginning of the curve at the upper part of the heads. These braces will have their nuts set up on washers riveted to the outside of the boiler-heads.

Seven $1\frac{9}{16}$-inch braces, secured to angle-irons, riveted on fronts of combustion-chambers, by means of crow-foot links, as shown in drawings. Such of these braces as are run diagonally will have beveled wrought-iron washers on both sides of front head, while the others will have washers on the outside only.

Six $1\frac{9}{16}$-inch through braces, connecting the heads at the lower parts between and below the furnaces. Beveled wrought-iron washers will be riveted on both sides of the back head and on the inside of front head. The stiffening-rings of the lower man-holes will be extended to form seats for the outside nuts of these braces in place of washers.

The combustion-chambers will be stayed to each other and to the shell of the boiler by screw-stays, spaced 7 inches horizontally and vertically, screwed into both sheets and fitted with nuts—the nuts to be set up on beveled washers where stays do not come square with the plates. The screw-stays will be $1\frac{1}{16}$ inches diameter except those in the vertical rows nearest the adjacent sides of the combustion-chambers, which will be $1\frac{1}{4}$ inches diameter. The holes for screw-stays will be tapped in both sheets in place.

The tops of the combustion-chambers will be braced to the back head of boiler by gusset-plates and 1¼-inch heel-braces, placed directly over the rows of screw-stays. The gusset-plates will be secured to the tops of combustion-chambers by socket-rivets, as shown on drawings.

The bottoms of the combustion-chambers will be stiffened by angles.

All screw-stays and all screwed braces will have raised threads.

All braces will be made without welds.

RIVETED JOINTS.

The longitudinal joints of boiler-shells will be butted, with ⅞-inch straps inside and ¾-inch straps outside, and treble-riveted. Circumferential joints will be lapped and double-riveted. Joints in furnaces and combustion-chambers will be single-riveted. Rivets will be of steel. Edges of all plates in cylindrical shells, and of all flat plates where not flanged, will be planed. Edges of flanges will be faired by chipping or otherwise, as may be approved. Plates in cylindrical shells must not be sheared nearer the finished edge than a distance equal to the thickness of the plate along the circumferential seams, and not nearer than two thicknesses along the longitudinal seams. No plate must average less than the specified thickness along the longitudinal seams. All rivet-holes in shell-plates will be drilled in place after bending. Hydraulic riveting will be used wherever possible. In parts where hydraulic riveting cannot be used, the rivet-holes will be coned and conical rivets used. Seams will be calked on both sides in an approved manner. Longitudinal seams will break joints. All joints will be as shown on drawings.

BOILER MAN-HOLES AND HAND-HOLES.

There will be four 12 x 15-inch man-holes in the front head of each boiler. Each of these man-holes will have a stiffening-ring riveted on the outside of the boiler-head. The plates

will be of cast-steel, in dished form; each plate secured by two wrought-iron dogs and two 1¼-inch studs with square nuts. Each plate will have a convenient handle.

There will be a 12 x 15-inch man-hole in each boiler-shell near the top of the front end; these holes to be right and left as regards the smoke-pipe. Each of these man-holes will have a raised cast-steel frame, flanged and riveted to the shell of boiler, and with a cast-steel cover bolted on.

There will be two 6 x 8-inch hand-holes in each boiler-head, with cast-steel plates secured by dogs and bolts.

All plates, dogs, and nuts will be indelibly marked to show to what holes they belong.

FURNACES.

Each furnace will be in one piece, ½ inch thick, and corrugated; 3 feet 6 inches least internal diameter, and 3 feet 10 inches greatest external diameter. They must be perfectly circular in cross-section at all points. They will be riveted to flanges of front heads and will be flanged and riveted to combustion-chamber plates. The corrugations of adjacent furnaces will be made to alternate.

GRATE-BARS AND BEARERS.

The grate-bars will be of wrought-iron, of approved revolving or shaking pattern. They will be so fitted that they can be readily worked under forced draft without opening the furnace or ash-pit doors, and without allowing an escape of air or gases. They will also be so fitted as to be readily removed and replaced without hauling fires. The bars at sides of furnaces will be made of cast-iron to fit the corrugations.

The bearers will be made of wrought-iron, supported by wrought-iron lugs bolted to the furnace-flues.

BRIDGE-WALLS.

They will be made of cast-iron, so fitted as to be readily removable. They will extend back to the back of combustion-

chambers so as to leave no place behind them where dirt can accumulate. They will be finished with fire-brick or other approved refractory material.

FURNACE-FRONTS.

They will be made with double walls of wrought-iron, bolted to a light frame. The space between the two walls will be in communication with the ash-pits and with the space between the inner and outer plates of the furnace-doors. Dampers will be fitted to regulate the amount of air admitted to this space. The upper part of the inner plate of furnace front will be perforated as directed. The dead-plates will be made of cast-iron, and fitted so as to be easily removable. The door-openings will be as large as practicable. There will be a beading on the inside of the door-frame in wake of the inner plate of door to make the clearance as small as possible.

FURNACE-DOORS.

They will be made with inner and outer walls of wrought-iron secured together with socket-bolts. The outer plates will be flanged back and made a tight joint against the furnace-fronts. The inner plate will have as little clearance as possible when closed. It will be perforated as may be directed. The space between the inner and outer walls will be in free communication with the ash-pit, through the furnace-front, so as to prevent gases leaking out around the door. There will be three hinges to each door, all of wrought-iron. The upper hinge will be so made as to support the weight of the free end of the door, and so fitted that the sag can be easily taken up. The latches will be of wrought-iron.

AIR-DUCTS.

From each of the fire-room blowing-fans a wrought-iron trunk will lead vertically down to the space underneath the fire-room floor-plates, which will be bolted down to form an air-tight duct. Or, if preferred, a separate duct may be

built under the floors, leaving the floor-plates loose. Each main air-duct will be fitted with a damper which can be closed in case its blower is stopped. The ducts will be so arranged that either blower can deliver into the furnaces on both sides of fire-room. The wrought-iron sides of ducts will be not less than $\frac{3}{16}$ inch thick. Plates will be removable where necessary to get at boilers for repairs. From the main air-duct, branches will lead to all ash-pits, each fitted with a door in front of ash-pit and each fitted with a damper. These dampers will be so fitted as to be easily removable for repairs, and will each be provided with a lever and catch for opening and closing; to be so fitted that the amount of opening can be quickly and easily graduated.

The dampers must be made to work easily, and when closed must be practically air-tight. The air-ducts will be so arranged that the lower man-holes will be easily accessible. If necessary to make parts of the ducts removable for this purpose, the removable sections will be fitted with handles and with beckets for hanging them on hooks provided for the purpose.

The air-ducts below the floors must be water-tight, and so proved. All air-ducts will be tested for air-tightness under the pressure needed to produce the requisite combustion.

Man-holes will be arranged in main air-ducts where directed, with suitable covers. The covers of man-holes in fire-room floor-plates will be sufficiently heavy to be kept down by their own weight, and will rest upon suitable packing. A 2-inch suction will lead from the lowest part of each main air-duct to the auxiliary feed-pump. Sluice-valves of approved pattern, of the same size as those fitted in the water-tight bulkheads of the vessel, will be fitted in the walls of the air-ducts, if necessary, in order to secure a free fore-and-aft water passage.

ASH-PIT DOORS.

They will be made of $\frac{1}{8}$-inch wrought-iron, stiffened with angle or channel-iron. They will be fitted with asbestos or other approved material to make an air-tight joint where fast-

ened to air-ducts; this packing material to be so fitted as to be protected from injury, and so as to be readily renewed. Each door will be fastened in place by wrought-iron buttons bolted to lugs on the walls of the air-duct, each button setting up on a wedge riveted to the door. Each door will have two wrought-iron handles, two wrought-iron beckets to fit hooks on uptake-doors, and an eye for slinging by.

LAZY-BARS.

A lazy-bar with the necessary lugs will be fitted in the front of each ash-pit. Also portable lazy-bars for the furnaces.

ASH-PANS.

Ash-pans of $\frac{1}{4}$-inch wrought-iron, reaching from the front of furnace-flue to bridge-wall, will be fitted to all furnaces.

CIRCULATING-PLATES.

Each boiler will have circulating-plates fitted at each side of each nest of tubes, as shown in drawing. They will be of steel, $\frac{1}{8}$ inch thick, in sections as shown in drawing. Each section will have two clips at upper and one at lower end for supporting it from the stay-tubes as shown. The plates will be well painted all over with two coats of approved paint or cement.

UPTAKES.

They will be made of wrought-iron, No. 8 B. W. G., built on channel-iron and stiffened with angle-irons, and will be bolted to boiler-heads and shells. They will be bolted to the lower plates of smoke-pipe with slotted holes to allow for expansion.

The uptakes will be carried up clear of the upper deck. There will be an athwartship division-plate in each uptake to keep the gases from the adjacent boilers separate. There will also be a fore-and-aft division-plate extending to the armor bars for the purpose of keeping separate the gases from the boilers on opposite sides of the fire-room. Outside of the up-

takes will be a jacket inclosing a 3-inch air-space; this jacket will be made of No. 12 B. W. G. iron, and will extend from the tops of uptake-doors to e tops of the uptakes.

The space between the plates of the uptake will be filled with an approved incombustible non-conducting material.

UPTAKE-DOORS.

The uptake-doors will be made of double shells of iron of the same thickness as uptakes. The space between the shells will be filled with the same non-conducting material as in uptakes.

The hinges and latches will be made of cast-steel or wrought-iron. Each door will have two hooks for hanging the ash-pit doors and a hook for a rope for hoisting the same.

Each door will also have an eye near its top for handling.

SMOKE-PIPES.

There will be two smoke-pipes, about 60 feet in height above the grates of the lower furnaces. The lower parts of the pipes will be shaped to connect with the uptakes, and will be built of No. 7 B. W. G. iron or steel. The upper parts will be oval in cross-section, 6 x 8 feet in diameter, built of No. 9 B. W. G. iron or steel. The flat sides of the oval part will be strengthened by cross-stays riveted to angles. The pipes will be well stiffened by angles.

Each pipe will be finished at the top by an angle-iron to which the stay-shackles will be secured, and by a hood covering the casing, to which will be secured shackles for slinging painters. Each pipe will be strongly stayed by guys and turnbuckles of approved dimensions and pattern. All joints will be butted and strapped. The pipes will be supported in an approved manner, so that their weight will not come on the uptakes.

From its junction with the uptakes to about six inches below the hood at top each smoke-pipe will be surrounded by a casing, leaving an annular space of 3 inches. The casing will be

made of iron, No. 12 B. W. G., and strengthened by angle-irons. It will be butted and strapped, flush-riveted on the outside and open top and bottom. It will be stayed to the pipe and will be finished with a half-round iron at top. There will be doors through this casing and through smoke-pipe about on a level with the main deck.

Above the smoke-pipe hatch an oval iron casing, No. 12 B. W. G., leaving an annular space of about 6 inches, will extend for about 5 feet, and will be finished by half-round iron. About 1 foot above this there will be a hood carried by the smoke-pipe casing.

There will be a ladder on the outside of each pipe, on the forward side, reaching to the top; these ladders to be made of round iron, bent and riveted to the pipes.

SMOKE-PIPE COVERS.

Each smoke-pipe will have a permanently-fixed cover made of wrought-iron, No. 11 B. W. G., built on angles in a slightly dished form and supported by angles riveted to the smoke-pipe. The cover will be placed about 33 inches above the top of the smoke-pipe so that it will not interfere with the exit of the gases, and will overlap the smoke-pipe about 18 inches all around.

BOILER-SADDLES.

Each boiler will rest in two saddles, which will be provided by the constructors of the hull. Angle-irons will be riveted to the boilers to fit the saddles. They will be bolted to the saddles with allowance for expansion.

BOILER ATTACHMENTS.

Each main boiler will have the following attachments, viz:

One steam stop-valve;
One dry-pipe;
One main feed check-valve with internal pipe;
One auxiliary feed check-valve with internal pipe;

One bottom-blow valve with internal pipe;
Two safety-valves;
Two steam-gauges;
Two glass water-gauges;
Four gauge-cocks;
One sentinel-valve;
One salinometer-pot;
One drain-cock;
One air-cock;
One approved circulating apparatus;
One cock with thread for the attachment of a syringe.

All external fittings will be of composition unless otherwise directed. All fittings will be flanged and through-bolted or attached in other approved manner. All cocks, valves, and pipes will have spigots or nipples passing through the boiler-plates. All internal pipes will be of brass, No. 14 B. W. G., and must touch the plates nowhere except where they connect with their external fittings. The internal feed and blow-pipes will be expanded in the holes in boiler-shells to fit the nipples on their valves, and they will be supported where necessary in an approved manner. The stems of all valves on boilers are to have outside screw-threads. The internal feed and blow-pipes are to be arranged to come between the corrugations of furnaces.

BOILER MAIN STOP-VALVES.

There will be an 8-inch self-closing stop-valve, with horizontal spindle, on each boiler. The valve will be bolted to the front head of each boiler as shown, there being a spigot beyond the flange long enough to afford a good fastening for the dry-pipe. There will be on the valve-chamber a $7\frac{1}{2}$-inch nozzle, placed at right angles to the axis of the valve, to which the $7\frac{1}{2}$-inch steam-pipe, connecting the pair of boilers on each side, in each compartment, will be bolted.

Each stop-valve chamber of the after boilers in after compartment, and forward boilers in forward compartment, will

have, in addition to the 7½-inch nozzle, a 9-inch nozzle placed as shown, and the chamber will be enlarged to suit the larger nozzle. There will be a bracket cast on each valve-chest, to be bolted to the boiler-head for additional stiffness. A screw-sleeve, with suitable hand-wheel, will be fitted for closing the valve; also a spindle and handle for opening the valve.

BOILER AUXILIARY STOP-VALVES.

There will be on each of the two extreme forward boilers, and on each of the two extreme after boilers a 5-inch screw stop-valve, bolted to the boiler-shell and placed where directed. Each of these valves will connect with an internal dry-pipe, similar to the main dry-pipes.

DRY-PIPES.

There will be in each boiler, as high as possible and properly supported, an 8-inch brass dry-pipe, No. 14 B. W. G., extending nearly the length of the boiler, perforated on its upper side with longitudinal slits 3 inches long, ⅛ inch wide, ¼ inch between slits, in groups as shown. The valve end of the pipe will be expanded so as to fit the spigot of the stop-valve nozzle, and will be secured to it by 4 pins. The pipe will be closed at the inner end and have a ½-inch drain-hole in its under side near each end.

The boilers having auxiliary stop-valves will also be provided with smaller dry-pipes connecting with them.

FEED CHECK-VALVES.

The main and auxiliary check-valves will each be 2½ inches in diameter. They will be fixed on the shell at front ends of the boilers, but entirely separate from each other, and will be fitted with internal pipes, the main feed-pipes leading above the tubes and pointing downward in the water-spaces between the nests of the tubes and between one of the wing-nests and shell, as shown. The auxiliary internal feed-pipe will lead downward to near the bottom of the boiler, as shown.

The valve-cases will be so made that the bottom of the outlet-nozzle shall be at least ½ inch above the valve-seat. The valves will be assisted in closing by phosphor-bronze spiral springs. These valves will have polished brass bent bar-handles in lieu of hand-wheels.

SAFETY-VALVES.

Each boiler will have two 4½-inch spring safety-valves, placed as near the front of boiler as possible; the two valves to be in one case. Each valve will have a projecting lip and an adjustable ring for increasing the pressure on the valve when lifted; or an equivalent device for attaining the same result. They will be adjustable for pressure up to the test pressure; the adjusting mechanism to have an index to show the pressure at which the valve is set, and a lock to prevent tampering with the adjustment. The locks on all safety-valves will be alike. The springs will be square in cross-section, of first quality of tool-steel, and will be nickel-plated. They will be of such a length as to allow the valves to lift one-eighth of their diameters when the valves are set at 135 pounds pressure. They will have spherical bearings at ends, or be connected to the compression-plates in such a manner as to insure a proper distribution of pressure. They will be inclosed in cases so arranged that steam will not come in contact with the springs. The spring-cases will be so fitted that the valves can be removed without slacking the springs. The valve-stems will fit loosely in valves; to bottom below the level of the seats, and to be so secured that the valves may be turned by a wrench or cross-bar on top of stem. The valves will be guided by wings below and in an approved manner above. The valves will be fitted with mechanism for lifting by hand from main deck and fire-rooms; the mechanism for each pair of valves to be such that the valves will be lifted in succession. All joints in the lifting-gear will be composition bushed. The outlet nozzle will be in the base casting, so that the joint at the escape-pipe will not have to be broken when taking the valves

out. The casings, valves, and spindles will be made of composition. The valve-seats will be of nickel, or equivalent metal of approved kind. A drain-pipe will be attached to each safety-valve casing below the level of the valve-seats, leading to the bilge.

SENTINEL-VALVES.

Each boiler will have, upon each end, a sentinel-valve of $\frac{1}{2}$ square inch in area. It will have a sliding weight on a notched lever graduated to 150 pounds pressure.

BOTTOM BLOW-VALVES.

There will be a 2-inch bottom blow-valve on each boiler, bolted to the shell near the front, on the side of the boiler nearest the smoke-pipe. The valves will close against the boiler-pressure. An internal pipe will lead from each valve to near the bottom of the boiler.

BLOW-PIPES.

A 2-inch pipe will connect with all bottom blow-valves in each compartment and with a sea-valve in the same compartment. This pipe will have a nozzle for the connection of a pipe for pumping out the boilers. There will be a straightway-valve in the blow-pipe as near the sea-valve as possible. All joints will be flange-joints.

BOILER PUMPING-OUT PIPES.

A 2-inch pipe will connect the bottom blow-pipe in each compartment with the auxiliary feed-pump in the same compartment, with a screw stop-valve above the floor near the pump.

STEAM-GAUGES.

There will be two spring steam-gauges, equal to "Lane's improved", on each boiler, with $8\frac{1}{2}$-inch dials, one graduated to 160 and the other to 230 pounds. Each gauge will have an independent connection with its boiler and be fitted with a three-way cock and a coupling for attachment of a test-gauge.

BOILER WATER-GAUGES.

Each boiler will have two glass water-gauges of approved pattern. Each gauge will be placed at the side of the boiler and will have 1½-inch pipes leading to top and to near bottom of boiler, with a valve in each close to boiler. The shut-off and blow-out cocks are each to have at least ½ inch clear opening, and will be packed cocks, with levers and rods for working from fire-room. The glasses will be about 16 inches in exposed length, with the lowest exposed part about one inch above the highest heating surface. The glasses will be well protected. A brass index-plate, with letters and arrows cast in relief, will be fixed close to each gauge-glass to show the height of the top of combustion-chamber. The blow-out cocks will have drain-pipes leading to bilge, with union joints.

GAUGE-COCKS.

There will be four asbestos-packed gauge-cocks of approved pattern on each boiler, with rods and levers for working from fire-room. Each cock will have an independent attachment to the boiler. They will be spaced about 6 inches vertically, the lowest one being about 4 inches below the highest heating surface. Each set of cocks will have a drip-pan and a drain-pipe leading to bilge.

SALINOMETER-POTS.

There will be a salinometer-pot of approved pattern connected to each boiler. They will be placed in groups in the fire-rooms where directed.

BOILER DRAIN-COCKS.

Each boiler will have a 1-inch drain-cock of approved pattern.

BOILER AIR-COCKS.

Each main boiler will have a ½-inch air-cock at its highest part, with a ½-inch copper pipe leading to bilge.

CIRCULATING APPARATUS.

There will be fitted to each boiler an approved device for circulating the water in the boiler while raising steam. Each of these will be fitted where directed and have a stop-valve close to boiler. They will take steam from the auxiliary steam-pipe, with stop valve in fire-room.

ZINC BOILER PROTECTORS.

Each boiler will have thirty-nine rolled zinc plates 12 x 6 x $\frac{1}{2}$ inch. Each plate will be bolted to a wrought-iron strap, which will be clamped to the stays. Each strap will be filed bright where in contact with zinc and stay, each stay being also filed bright at contact point. After being bolted in place the outside of the joints will be made water-tight by paint or approved cement. The zinc plates will be located as shown in the drawings.

MAIN FEED-PUMPS.

There will be in each fire-room a vertical duplex pump of approved pattern, with packed pistons or packed plungers, for a main feed-pump. It will have water-cylinders, 6 inches in diameter and 10 inches stroke, or of equivalent commercial dimensions. The water-valves will be metallic, of approved kind. The pumps will be so arranged that the packing of the water-pistons can be got at from the tops of cylinders. The steam-cylinders must be of sufficient size to work the pumps at the required speed to feed the boilers under forced draft. The exhaust-cushion must be adjustable. All working parts will be of wrought-iron or steel.

Each main feed-pump will draw water from the feed-tanks only and deliver into main feed-pipe only. If the steam-valve is moved by a supplemental piston the valve must have a positive motion near the end of the main piston stroke to prevent piston striking cylinder-head. If a supplemental piston is used its motion must be horizontal.

AUXILIARY FEED-PUMPS.

There will be in each fire-room a vertical duplex pump of the same kind and same water capacity as the main feed-pump. It will be connected to draw from the sea, feed-tank, bilge, air-ducts, or boilers at will, and to deliver either into auxiliary feed-pipe, fire-main, or overboard through the Kingston valve in its own compartment.

These pumps will have their steam-cylinders adapted for use as fire-pumps with steam of 60 pounds pressure.

In each fire-room there will be a hose connection on fire-main, furnished with a screw stop-valve.

FEED-PUMP PRESSURE-GAUGES.

Each main and auxiliary feed-pump will have a spring pressure-gauge registering from zero to at least 250 pounds per square inch.

ASH-HOISTS.

One ventilator in each fire-room will have vertical guide-strips of iron on the inside, and be fitted with all the necessary gear for hoisting ashes.

An ash-hoisting engine of approved design will be fitted in each fire-room hatch or such place as may be directed, of sufficient power to hoist 300 pounds from the fire-room floor to the deck in five seconds with steam of 60 pounds pressure.

It will have a reversing-gear, to be worked from the fire-room and from deck, with approved adjustable safety-gear to prevent overwinding and to stop the engine when the ash-bucket reaches the fire-room floor. It will also be fitted with an approved brake to control the drum. The ash-hoist will be fitted with the necessary sheaves, whip, and all appliances necessary for handling ash-buckets.

FIRE-ROOM BLOWERS.

There will be two blowers of approved pattern in each boiler compartment.

These blowers must be capable of supplying to the fires continuously, with ease, sufficient air to maintain the maximum rate of combustion. They will take air from the fire-room in such manner as to thoroughly ventilate it, and deliver into the air-ducts. Light iron screens will be fitted in fire-rooms so that all air going to blowers can be taken from the hatch at the farther end of fire-room, and shall pass along the fire-room at a sufficiently low level to keep fresh air at the firemen's stations.

The spindle-bearings must be accessible while the blowers are in motion, and will be of anti-friction metal in composition boxes, and, together with their lubricating apparatus, must be thoroughly protected from dust.

BLOWER-ENGINES.

Each blower will be driven direct by an inclosed three-cylinder single-acting engine of an approved design, and of sufficient power to run the blower at full speed with steam of 100 pounds boiler pressure. The engine-valves must be of the slide or piston type.

All working parts must be closed in, but easily accessible for overhauling. The lubrication must be automatic and thorough. The throttle-valve in the steam-pipe of each blowing-engine will be arranged to be worked from the fire-room floor, with suitable index to show how much it may be open. The steam-pipe for each blower will connect with auxiliary steam-pipe.

The shafts of blower-engines will be so fitted that a portable revolution-indicator can be quickly and easily applied without removing any part of the mechanism.

AIR-PRESSURE GAUGES.

An approved gauge, equal to those made by the E. P. Gleason Manufacturing Company, will be fitted in each fire-room to show the pressure in each main air-duct.

A portable gauge will also be supplied to each fire-room, with conveniences for connecting it to the furnaces, uptakes, and wherever desired to measure the air pressure.

All these gauges will indicate pressures in "inches of water".

FIRE-TOOL RACKS.

Racks will be fitted in each fire-room in convenient places for holding all necessary fire-tools.

ASH-DUMPS.

From each ash-hoist, on the upper deck, permanent overhead rails, suitably supported, will lead to the nearest ash-chutes on each side of the ship. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash-buckets. At the top of each ash-chute a dumping-hopper of approved design will be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be balanced dump-buckets, with all necessary gear complete. All the ash-hoisting and dumping-gear will be such that the buckets will not have to be lifted by hand.

ASH-SPRINKLERS.

A valve for wetting down ashes will be fitted in each fire-room where directed, and will be fitted with all necessary hose, couplings, and nozzles.

STEAM TUBE-CLEANERS.

A steam tube-cleaner, of approved design, will be fitted in each fire-room. Steam will be taken from the auxiliary steam-pipe. Sufficient length of steam-hose will be provided to easily reach all the tubes.

STEAM-CAPSTAN AND WINDLASS.

There will be fitted, where shown on the plans of the hull, a steam-windlass and capstan. The capstan will be so fitted

that by means of it the windlass may be worked by hand, or the capstan may be entirely disconnected from the windlass. It will also be so fitted that it may be worked by the steam-gear of the windlass.

The engine for driving the windlass will be double and will be fitted with reversing-gear. It will be arranged to exhaust into the condensers, or into the atmosphere by a separate exhaust-pipe.

The windlass will have two wild-cats fitted for 2⅛-inch chain. Each wild-cat will be fitted to be easily thrown into or out of gear by a locking device, and will be controlled by a friction-brake. The brake and locking device of each wild-cat will be so arranged that both levers will be within reach of one person. Each wild-cat will be fitted with an index to show the length of chain which passes over it. There will be a rope-drum on each end of the main shaft, of proper diameter and strength to handle a steel-wire hawser 1½ inches in diameter. The windlass must prove capable of raising both bower-anchors at the rate of six fathoms per minute with steam of 80 pounds pressure at the boilers, and of exerting an aggregate stress of 280,000 pounds on both bower-chains with steam of 130 pounds pressure at the boilers. If worked by a worm, the thrust-bearing must be adjustable for wear. The worm will be of bronze, and the worm-wheel will be fitted with an automatic lubricating device.

All gear-wheels will be of cast-steel with cut teeth. All working parts will be of forged steel, finished all over. The pawls of windlass and capstan will be of wrought-iron or steel. The capstan will rest on ball-bearings; its base will be so made as to prevent water working down around the spindle; its top will be finished by a polished brass plate; the capstan-bar sockets will be fitted with polished brass stoppers; capstan bars will be supplied.

All parts not capable of being easily oiled by hand while running will be fitted with automatic lubricators.

A drip-pan will be fitted under the windlass-engine with a drain-pipe leading to the bilge or overboard. There will be an approved automatic reducing-valve in the steam-pipe close to the engine. The steam-pipe will have an automatic trap-discharge at its lowest point, with a drain-pipe leading to the feed-tanks. There will be a steam-gauge between the reducing-valve and the controlling-valve. There will be straightway stop-valves in the steam and exhaust-pipes. The cylinders and valve-chests of the engines will be completely lagged.

The windlass and capstan will be fitted in place, complete and ready for working. An oiled canvas cover will be supplied for the capstan.

STEAM-WINCHES.

There will be fitted on the superstructure-deck, where directed, a reversible double-geared steam-winch of approved design, of sufficient power to hoist 4 tons at a speed of 60 feet per minute with steam of 130 pounds pressure at the boilers. It will have a rope-drum or gypsy on each end of its main shaft; the drums on both ends to be of the same diameter.

There will also be a special reversible steam-winch for hoisting torpedo-boats, with a grooved drum to suit the wire rope used for hoisting. It must be capable of hoisting 14 tons at a speed of 60 feet per minute with steam of 130 pounds pressure at the boilers.

All parts of both winches will be fitted and finished in the same manner as similar parts of the windlass and capstan. The engines will exhaust into the main escape-pipe. The smaller winch will also be fitted to exhaust into the condensers. Friction-brakes will be fitted to the drums unless worked by worm-gear. The engines of both winches must be double-cylinder. An oiled canvas cover will be supplied for each winch.

Hydraulic hoists may be fitted, if desired, instead of steam-winches; but must be no heavier than efficient steam-winches, nor occupy any more space. They must be of approved design.

STEAM-STEERING GEAR.

A steam steering-engine of approved type will be supplied and fitted where shown on the plans of the hull. It must prove to be capable of putting the helm hard over from amidships in five seconds when the vessel is going ahead at or below a speed of 17 knots per hour with a boiler-pressure of 130 pounds per square inch. It must also be sufficiently powerful to work the rudder with the vessel going astern with the full engine power. There will be approved means of quickly changing from steam to hand-steering and *vice versa*.

All gear-wheels will be of cast-steel with cut teeth. Worms, if any, will be of bronze. All other working parts of the engine will be of forged-steel. A drip-pan will be fitted under the entire engine, with a drain-pipe leading to the bilge. The engine will be connected with the auxiliary steam and exhaust-pipes elsewhere specified. The steam-pipe will have an automatic trap connected at its lowest part, with a drain-pipe leading to the feed-tank. There will be an approved adjustable reducing-valve in the steam-pipe close to the engine, so that the pressure may be varied to suit the work. There will be a steam-gauge connected with the steam-pipe between the reducing-valve and the controlling-valve. There will be straightway stop-valves in steam and exhaust-pipes. All working parts will be supplied with automatic lubricators with sufficient oil capacity for four hours running. The cylinders and valve-chests of the engine will be completely lagged. No part of the steam-steering gear except the mechanism for working the valves from deck will be above the armored deck.

Hand-wheels for operating the steam-steering gear will be fitted in the conning-tower, the pilot-house, and on the after superstructure-deck. These wheels will have connections to an electric motor, which will work the engine-valves in such a way that the valves must follow the motion of the hand-wheels. There will be separate connections from each of these wheels to the steering-engine. There will be three sepa-

rate wire connections from the conning-tower hand-gear other steering-engine, leading in different directions, so that there will be electric connections when two wires are disabled. The current for working the valves will be taken from the dynamos elsewhere specified. The hand-wheels will be about 30 inches in diameter, made of mahogany with locust spokes, finished similarly to the hand-steering wheels. Each of these hand-wheels will have the same number of spokes as the hand-steering wheels, and will be so fitted that any given number of turns of the wheels will give the same helm-angle as the same number of turns of the hand-steering wheels. The gear must be so fitted that the force required to be exerted on any hand-wheel at a radius of 15 inches from the center will not exceed 10 pounds. There will also be a hand-wheel at the engine itself, so that the engine may be operated when the deck-gear is disconnected. All metal work above the main deck will be of bronze or brass. All parts passing through water-tight bulkheads will be fitted water-tight. All working parts of engine and hand-gear connected to it will be finished all over.

A direct-acting hydraulic steering-gear will be supplied, if directed, instead of a steam-gear. In this case an additional hydraulic pump will be supplied, of proper size to furnish water for the steering-gear; this pump to be, in general, similar to the main hydraulic pumps. The acceptance of the hydraulic-gear will be conditional upon its being no heavier than an efficient steam-gear.

Stops will be fitted to the steering-engine valve-gear so that the engine cannot run beyond the position of corresponding helm-angle. Stops will also be fitted to each hand-wheel.

HYDRAULIC PUMPING MACHINERY.

There will be a hydraulic pumping plant for each turret, to furnish water for revolving the turret, working the guns, etc. Each plant will consist of at least two independent pumps of approved design. Other things being equal, the lightest pump which will do the work efficiently will be

selected. The combined capacity of the pumps for each turret will be 500 gallons per minute at a pressure of 600 pounds per square inch. The water ends of the pumps will be entirely of composition or bronze.

All piston-rods, side-rods, cross-heads, valve-stems, links and levers of valve-motions, shafts and rock-shafts, will be made of forged steel. If supplemental pistons are used for the purpose of moving the main valves, the latter will also have a positive motion, which will prevent the piston striking the cylinder-heads in case of the supplemental pistons not acting quickly. If duplex pumps are used, the valve-motion must be adjustable. If direct-acting pumps are used, they must be so adjusted that, when performing the duty above specified, each piston shall make a stroke of such length that the lineal clearance at each end shall not be more than ten per cent. of the stroke. Straightway stop-valves will be fitted for the purpose of shutting off either pump at steam and water ends in case of accident.

An approved automatic pressure-regulator will be fitted; also an adjustable relief-valve. Before being put on board the plant will be tested, to prove that the requisite duty can be performed, and that the regulator will stop and start the pumps promptly when required, without allowing the water pressure to fall below 550 pounds pressure. The above-specified duty is to be performed with 100 pounds steam-pressure at the pump-throttle. The pump-valves will be metallic and easily accessible. The steam piston-rods will have metallic packing of the same kind as specified for main engines.

The pumps must either have packed pistons or packed plungers; if the packing used is other than ordinary commercial packing, spare packing will be supplied. The pumps must be proved incapable of getting in any position where they will not be started promptly when steam is turned on. They must work without pounding when performing light or heavy duty.

A wrought-iron water-tank for each plant, of 150 gallons capacity, will be fitted where directed, and connected with the

suction-side of the pumps and with the discharges from the hydraulic engines. These tanks will have drain-valves with pipes leading to the bilge. Each tank will have a neat brass label, plainly inscribed, "Fresh-water only will be used in this tank". Connections will be made to each tank from the nearest auxiliary feed-pump for the purpose of filling it with fresh water.

Each tank will have a close top, bolted on, and will be fitted with a well-protected glass-gauge and a vent-pipe.

The hydraulic pumps will be set in water-tight beds with drains leading to the bilge. The drains of the steam-cylinders will be piped to the top of the fresh-water tank; also having cocks by which the cylinders can be kept drained when not in use.

All parts of the hydraulic system, except suctions, will be tested to 1,200 pounds water-pressure.

HYDRAULIC PIPING.

All hydraulic pipe, except where otherwise directed, will be lap-welded iron or steel, screwed into wrought-iron or cast-steel flanges, which will be turned male and female so that the packing cannot be squeezed out.

All joints will be made with leather or approved equivalent material. The sizes of pipes will be sufficient to allow the pumps to perform the prescribed duty when fitted on board and doing their regular work.

All pipes will be tested when in place to 1,200 pounds pressure per square inch. All stop-valves will be straightway, of composition. All valves for admitting water to and exhausting from the turret-turning engines, and other hydraulic gear herein specified, will be balanced-valves, made perfectly tight by renewable packing, and working as easily as any that can be procured. Air-cocks will be fitted at the highest parts of any loops that may be made in the pipes. A pipe of sufficient size to take all the water from either set of pumps will be fitted below the armored deck to connect the pumping plants

of the two turrets, so that either plant can be used on either turret. A double composition pipe will be so fitted as to revolve with the turret, containing passages for the pressure and exhaust-water. The lower part of this pipe, below the armored deck, will revolve in a composition box fitted with cup-leather packing, which will divide it into pressure and exhaust-passages. This pipe will be provided with a stuffing-box at the armored deck. The pump-discharge will deliver into this box, and from the exhaust side of the box a pipe will lead to the water-tank. The upper end of the double pipe, within the turret, will have pressure and exhaust-nozzles from which pipes, of such size as may be required by the Bureau of Ordnance, will be led to the valves controlling the running in and out and elevating of the gun. There will also be nozzles, if directed, for the connection of pipes for washing out the guns. Pipes will also lead direct from the pump-discharge to the ammunition-lifts and hydraulic rammers, and exhaust-pipes from these machines to the tank.

Pipes of sufficient size to utilize the full power of the pumping machinery will be fitted direct from the pumps to the turret-turning engine-valves.

TURRET-TURNING GEAR.

There will be two gears for revolving each turret. Each gear will consist of a three-cylinder hydraulic engine, driving by pinion and spur a horizontal shaft, which will carry a bevel-wheel meshing into a rack on the under side of and revolving with the turret.

The engines will be of approved type, each of sufficient power to turn the turret at the rate of one revolution per minute with the guns run out and the vessel on an even keel, and both together capable of revolving the turret at the same speed with the vessel heeled 10°. The turning-engines and gear will be fitted in water-tight beds, with drain-pipes leading to the bilge.

The rack on the bottom of each turret will be made of cast-steel, in sections, which will be firmly bolted to the turret in perfect alignment. There will be two sets of shrouded teeth, one stepped one-half the pitch in advance of the other.

The pinions for turning the turrets will be made of composition, with teeth to correspond to those on the turret-racks. Their shafts will be allowed a slight end-play to accommodate any movement of the turret. These pinions will run with their lower sides in an oil-box, and will have guards to prevent the oil being scattered. A copper drip-pan will extend around the turret chamber underneath the turret-racks.

The turning-engines will have stop-valves in their pressure and exhaust-pipes, so that either engine can be shut off in case of accident. The cylinders will have ample drain-cocks.

The engines will be started, stopped, and reversed by a valve which will change the pressure and exhaust-ports. There will be a hand-lever at each sighting station for controlling the movement of the turret. This lever will move the valve of a supplemental hydraulic cylinder through a floating-lever so that the piston will follow the motion of the hand-lever. The piston of this cylinder will work, through a system of levers, the reversing-valve of the turret-engines. The connection to the reversing-valve will be by means of a floating-lever, one end worked by the gear within the turret, and the other end so guided that when the turret revolves to its prescribed limit the reversing-valve will be automatically closed. The gear will also be so made that, in case of any leakage of the valves, allowing the turret to run beyond the prescribed limits, the engines will be reversed. The hand-levers in the turrets will be fitted with locomotive latches and quadrants. Relief-valves will be so fitted that, when the water is shut off the turning-engines, or the engines reversed, the momentum of the turret may be gradually overcome by the action of the valves. These valves will be adjustable as to the pressure of opening.

There will be a hydraulic locking device for each turret, consisting of a cylinder, plunger, and locking-bolt, with the

necessary valve-gear. The end of the bolt will be tapered to facilitate entering the locking-slots, of which there will be two, one for each loading position. An efficient inter-locking device will be applied, to prevent the locking-bolts being shot while pressure is on the turret-turning engines, and to prevent the latter being put in motion until the locking-bolts are withdrawn.

There will be a spring stop-valve in the pipe taking water to the hydraulic rammers at each loading station. This stop-valve will be so arranged that it will be kept shut, except when the locking-bolt, upon being shot into place, presses upon its stem and opens it, thus allowing the rammers to be worked. There will be a valve inside the turret, which when closed will prevent the withdrawal of the locking-bolt. This valve will ordinarily be kept open by a spring, but will be arranged to be closed by a lever, which will be struck by either rammer entering the turret. Upon the rammers being withdrawn the valve will be opened by its spring. The lever for working this valve will be placed over the rammers, and will be so formed and fitted as not to interfere with the working of the rammers or ammunition.

There will be an index inside each turret which will give indication of the approach to either loading station. This index will be turned by the revolution of the turret, and will be in plain view of the person stationed at the locking-bolt lever. There will be an electric-bell at each sighting station, which will be so arranged as to give warning of the approach to either loading station.

All cylinders, plungers, valve-boxes, and other parts in contact with water, will be made of composition, gearing of cast-steel and composition, and other working parts of forged-steel. All toothed gearing, except the turret-rack and pinion, will be cut. All working parts will be finished all over except where otherwise directed.

DYNAMOS.

There will be two dynamos, of approved type, which will be duplicates of each other, to supply current to work the steering-engine valves, the workshop machinery, and such other machinery as it may be found desirable to work by electricity, and to light the engine and fire-rooms when the ship's dynamos are not running. Each dynamo will be driven direct by an inclosed multi-cylinder engine, and will furnish a current sufficient for thirty-five 16-candle power incandescent lamps, or equivalent, when used for lighting only. The light produced must be at least 160-candle power for each brake horse-power of the engine. The potential must not be greater than 125 volts. The dynamos must be automatically regulated. One spare armature will be supplied, to fit both dynamos; also spare brushes and their fittings for both dynamos. The bearings of the dynamos will be self-lubricating.

DYNAMO ENGINES.

They will be of the single-acting inclosed multi-cylinder type, equal to Brotherhood's latest pattern. Each engine will be fitted with an approved governor, with a maximum speed variation of $1\frac{1}{2}$ per cent. either side of the standard. The engines will be proportioned for full power with 60 pounds boiler-pressure and atmospheric back-pressure. There will be an approved adjustable automatic reducing-valve in the steam-pipe to the dynamo engines. A spare piston, valve, and crank-pin brass will be supplied for each cylinder. The engines will be automatically lubricated throughout, with sight-feed cups.

ELECTRIC WIRES AND CONNECTIONS.

All conductors for electric connections will be of tinned copper wire of not less than 96 per cent. conductivity. The insulation of all fixed conductors will consist of a layer of non-sulphurous rubber, a layer of black rubber or okenite, a wrap-

ping of tape soaked in rubber, and an outside covering of pure lead piping. A sample of the wire, insulated as above, will be subjected to a dry-heat test of 250° F. for twelve hours without the insulation running or showing any signs of deterioration. If thought necessary, an insulation test will be made by soaking a suitable length of the insulated wire in salt-water for twenty-four hours, which after drying must have an insulation of not less than 1 megohm per foot; to be again soaked and dried as before, and in testing must show no appreciable decrease of insulation, nor any signs of deterioration or cracking of the insulation. The conductors will be set in hard wooden molding and secured with fiber staples. Each pair of conductors must be separated by at least one inch. The grooves of the molding will be large enough to take the wire easily without injuring the lead covering. The molding will be without capping in engine-rooms and fire-rooms; elsewhere it will be suitably capped, and must correspond with the surrounding wood-work. The molding in coal-bunkers will be extra heavy. The area of conductors will be fixed according to recognized standard tables of ampere capacity, which allow for a heating of 30° F., with a reserve of 50 per cent. above this. All joints and connections will be carefully soldered and made steam-tight, and wherever a change in size of wire is made a water-tight junction-box is to be used, with double pole fusing safety-strips. All connections for stationary lamps will be made steam-tight by stuffing-boxes or other approved means. Flexible conductors will be heavily insulated with rubber or okenite to stand 250° F., and will be covered with a heavy braided wire wrapping. Wires passing through water-tight bulkheads or decks will be provided with stuffing-boxes. Where passing through metal bulkheads or beams they will be protected by rubber ferrules. There will be a separate circuit for each engine-room and each fire-room, and at least two circuits for the coal-bunkers. There will be an approved switch near the dynamos for controlling all circuits. Two approved voltameters, with suitable connections,

will be supplied. If considered necessary, the completed system will be tested for insulation, which must not be less than 1,000 ohms for each volt.

LIGHTING APPARATUS.

Incandescent electric lights will be fitted for lighting all parts of the machinery, boiler, and coal-bunker compartments. At least 50 lamps will be fitted in the engine, boiler, and shaft-alley compartments, placed where directed. There will be one lamp in each coal-bunker compartment and one in each store-room. All lamps in engine-rooms will be spring-supported, unless otherwise directed. All lamps except those for local lighting, as at water-gauges, etc., will be of 16-candle power, the others of 10-candle power. All lamps will be inclosed in steam-tight globes and protected by neat brass guards. All sockets will be made of porcelain and will be steam-tight. Sockets will be made to suit the commercial sizes of lamps ordinarily furnished by the maker of the plant. Each lamp will have a water-tight switch. Lamps in coal-bunkers will be suspended from overhead, in the corner of the bunker where there is the least chance of injury. Switches for these lamps will be placed near the entrance to the bunker. Lamps at log-desks will have frosted globes and approved reflecting shades. All brass work about lamps and fittings will be nickel-plated. Four portable lamps of approved pattern will be supplied for each engine-room, and two for each fire-room. A suitable receptacle will be provided for each portable lamp. One connection will be fitted for each portable lamp with water-tight cover. Two spare lamps will be supplied for each one fitted. Lamps must be guaranteed for an average life of 600 hours.

WORKSHOP MACHINERY.

There will be fitted in the engineer's workshop the following:

A double-geared engine-lathe of the best make and of approved pattern. It will be of at least 12 inches swing and

34 inches between centers. It will be fitted with gears for cutting threads from 4 to 40 to the inch, and with four-grade cone-pulleys.

An approved shaping-machine, to work by hand or power, of at least 10 inches stroke and 8 inches traverse, with vertical adjustment of table, with three-grade cone-pulleys, and with chuck. It will have all the usual adjustments of first-class machines of its size.

An approved double-geared hand and power drilling-machine, with three-grade cone-pulleys, capable of drilling 1½-inch holes, with adjustable swinging-table and of at least 18 inches swing.

The tools above specified will be fitted where directed in the engineer's workshop. Each machine will be driven from a counter-shaft with cone-pulleys to suit the machine. Each counter-shaft will be driven direct by an approved reversible electric motor, regulated for constant speed. The switch for stopping and reversing will be within easy reach of the operators of the machine. Connections for running the motors will be made to the dynamos elsewhere specified.

DISTILLING APPARATUS.

The distilling apparatus, placed where directed, will consist of two evaporators and two distillers, with their accessories, having a combined capacity of 5,000 gallons of potable water per 24 hours at a temperature of not more than 90° F. when the cooling water is taken in at a temperature of 60° F.

The evaporators will be made with shells of plate-steel with welded seams. The heads and flanges will be of cast-iron and the coils of copper, tinned inside and out. They will be felted and lagged, and will each be fitted with a safety-valve, steam-gauge, glass water-gauge, gauge-cocks, salinometer-pot, and blow-valve. They will take steam from the auxiliary steam-pipe, and will be fitted with automatic traps and with drain-pipes leading to the feed-tanks. The shells of the evap-

orators will be tested to 50 pounds to the square inch and the coils and all parts subject to the boiler pressure to 205 pounds per square inch.

The distillers will be made with shells of sheet-brass, flanges and heads of composition, and coils of copper or brass, thoroughly tinned on both sides. The coils of each distiller will be divided into at least three parts, each with a separate inlet and outlet-valve.

A filter of approved design will be fitted to each distiller.

There will be efficient means for aerating the steam used in making distilled water.

There will be a steam-pump of approved pattern, and of a capacity of about 6 gallons per minute at ordinary speed, fitted to draw water from the filters and deliver it into the fresh-water tanks. The cylinders of the pump will be of "light service" proportions, for using steam of 60 pounds pressure. The water end of the pump will contain no copper or lead, or alloys of these metals. A pipe will lead from the atmosphere, above the ship's awnings, to the suction of the pump, with a regulating-valve, so that air can be forced into the tanks with the water. In the water-suction of the pump will be fitted an approved water-meter, made without copper or lead. The discharge-pipes to the fresh-water tanks will lead to the bottoms of the tanks, so that air forced in will rise through the water.

A pump of approved pattern and size will be fitted forfeeding the evaporators; also one to circulate the cooling water through the distillers; to draw water from a special sea-valve placed where directed. Also a pump, with metal valves, which can draw the condensed water from the evaporator and deliver it into the auxiliary feed-pipe. This pump will be placed below the level of the evaporators and will take the condensed water from the traps.

The water after leaving the distillers will be led forward by a proper pipe with connections for flushing the crew's water-closets, with branches to the officers' water-closets. A by-pass

pipe will be provided so that water may pass to the closets when the distillers may be shut off.

The evaporators and distillers will be so fitted that their coils can be easily removed for repairs. There must be no internal detachable joints in the coils of either evaporators or distillers.

WASH-WATER TANKS, ETC.

There will be one or more cylindrical wrought-iron tanks, of a combined capacity of 500 gallons, to hold fresh water for firemen's use. They will be fitted in the forward boiler compartment over the boilers. Each tank will have an overflow-pipe, without valve or cock, leading to the bilge, with the end in plain view from the fire-room; also a drain-pipe with its valve easily reached from the fire-room. Pipes will be led direct from the fresh-water outlets of the distillers for filling these tanks without passing the water through the filters; these pipes to have locked cocks.

There will be a Blake No. 00, or other approved pump of the same capacity, which will be connected as follows: to have suction-pipes from the feed-tank suction-pipe and from the tanks above mentioned, and to discharge into these tanks and into the tank in the firemen's wash-room; all pipes fitted with stop-valves close to pump. The pump will have a dead-weight relief-valve set at just sufficient pressure to allow the wash-room tank to be filled.

A cylindrical copper tank, of about 50 gallons capacity, will be fitted in the firemen's wash-room, and connected with the pump above specified. The tank will be supplied with a vent-pipe with a float-valve, which will close the vent when the tank is full. There will be a service-pipe from the tank, with a branch to each wash-basin, and one for filling buckets. Each of these branches will have a self-closing lever-faucet. In the service-pipe, close to the tank, will be a locked cock.

MAIN STEAM-PIPES.

A 7½-inch pipe will connect the main stop-valves of the forward and after boilers on each side of the fire-room in each

compartment. From the stop-valve of each forward boiler in the forward compartment a 9-inch pipe will lead inboard and connect with a 12-inch pipe, which will carry the steam to a separator, thence upward and aft to the port engine-room. A similar pipe will connect with the stop-valves of the after boilers in the after compartment, and will lead to the starboard engine-room. Immediately inside the engine-rooms a stop-valve will be fitted in each main steam-pipe with gear for working from both engine-rooms. These stop-valves will be connected by a 12-inch athwartship pipe. From each of these valves a 12-inch pipe, with a straightway stop-valve, worked from engine-room and from deck, will lead to the separator in the same engine-room; thence to the engine. There will be a straightway valve in each main steam-pipe between the separator and the engine; the auxiliary steam-pipe connecting with the main steam-pipe between this valve and the separator.

AUXILIARY STEAM-PIPES.

There will be an auxiliary steam-pipe extending through engine and boiler compartments and to the windlass, steering, dynamo, and ventilating-fan engines, and to the engineer's workshop. It will connect with the auxiliary stop-valves on boilers and with the main steam-pipe in each engine-room abaft the separator. It will have a stop-valve in the after part of each fire-room close to the bulkhead, one in each engine-room close to the bulkhead, and one in each connection with the main steam-pipe. Branches will extend to all auxiliary machinery herein specified. The pipe will be of sufficient size to supply all auxiliary machinery, including dynamos and ventilating-fans, when taking steam from abaft the separators. The auxiliary steam-pipe will be arranged, where possible, so that steam condensing in it may drain back to the separator. Where it is not possible to so arrange it, or wherever pockets necessarily occur, the pipe will be drained and trapped. All branches from the pipe to pumps or engines on a lower level

will have the stop-valve for such machinery close to the main pipe, with a spindle for working it from below, so that when the pump or engine is standing idle there will be no opportunity for water to collect in the vertical pipe leading to it, which must be blown out before starting.

AUXILIARY EXHAUST-PIPES.

An auxiliary exhaust-pipe, of sufficient size for all auxiliary machinery herein specified and for such other steam-machinery as may be fitted in the vessel, will be fitted and connected to all auxiliary machinery herein specified. It will have nozzles for all other auxiliary machinery. It will have valves to direct the exhaust-steam into either condenser, into either low-pressure cylinder, or into the atmosphere through the escape-pipe at will. At each connection with condensers and escape-pipe the auxiliary exhaust-pipe will be fitted with two stop-valves so as to minimize the chance of an air-leak.

The connection with the escape-pipe will be made below the armored-deck. All exhaust-pipes from engines above the armored-deck leading to the condenser will be fitted with valves below the armored-deck.

BLEEDER-PIPES.

A 5-inch branch from the main steam-pipe in each engine-room will lead to the condenser, with a stop-valve operated from the working-platform.

INTERMEDIATE AND LOW-PRESSURE STEAM-PIPES.

A 5-inch branch from the main steam-pipe will lead to each intermediate, and a similar pipe to each low-pressure valve-chest, each with a stop-valve.

SEPARATORS.

There will be in each main steam-pipe in fire-rooms a separator of approved design, with interior diaphram, and in each engine-room a centrifugal separator. They will be made

entirely of cast-steel and sheet-steel, each fitted with a well-protected glass gauge and an approved automatic steam-trap, with drains delivering into feed-tank or overboard at will.

MAIN FEED-PUMP EXHAUST.

The exhaust-pipes from the main feed-pumps, in addition to the connection with the exhaust-main, will be so arranged that the exhaust-steam can be turned into the feed-pump suction instead of into the auxiliary exhaust-pipe—chambers with suitable nozzles for this purpose being fitted in the suction-pipes.

ESCAPE-PIPES.

There will be a 10-inch copper escape-pipe abaft each smoke-pipe, extending to top, finished and secured in an approved manner. Each pipe will have branches leading to all the safety-valves in its boiler compartment. There will also be abaft the after smoke-pipe, fitted the same as the others, a 6-inch copper escape-pipe, connected to the auxiliary exhaust-pipe as above specified.

MAIN FEED-PIPES.

A seamless-drawn brass pipe, of the full size of the pump-discharge, will lead from each main feed-pump and discharge only into the main check-valves on the boilers in the same compartment, through branches, each of which will have a straightway-valve, with hand-wheel in a convenient position for regulating the feed. All parts of the pipes will be above the floors in plain view, and all joints made by flanges screwed on the pipes and bolted together.

AUXILIARY FEED-PIPES.

A similar pipe will lead from each auxiliary feed-pump to each auxiliary check-valve on boilers in its compartment. A pipe, with a valve in each boiler compartment, will connect with the forward and after auxiliary feed-pipes. These pipes will be fitted the same as the main feed-pipes.

FIRE-MAIN.

A pipe will extend fore and aft on the main deck, with an approved fire-plug of Navy standard size where directed in each compartment. This pipe will be connected with the discharges of the two engine-room fire-pumps, the two engine-room auxiliary pumps, and the two auxiliary feed-pumps. Three branches from this main will lead up to the upper deck and be fitted with fire-plugs. A branch from the main will lead to each magazine passing-room, one to the compartment abaft the engines on the platform-deck, and one to each compartment on the forward platform-deck. Each of these branches will be fitted with a fire-plug, and will be so connected that all of the fire-pumps can work on it. There will be a fire-plug in an approved position in each engine-room and each fire-room. Drain-pipes will be fitted to drain all parts of the fire-main and branches. A reverse coupling will be supplied, with adapters to suit the various sizes and threads of fire-hose commonly in use, for the purpose of filling the boilers with fresh water from hose, on shore, or on boats alongside.

PIPES THROUGH WATER-TIGHT BULKHEADS AND DECKS.

They will be made water-tight by stuffing-boxes, flanges, or other approved means.

Pipes must not be led in such manner that the angles or tees of bulkheads have to be cut. Holes through wooden decks, where pipes pass through, will have brass or copper thimbles, made water-tight, extending at least three inches above decks.

PIPES THROUGH COAL-BUNKERS.

They will be protected by iron casings, made in sections, easily removable for repairs. Pipes must not be led under openings of coal-chutes.

DRAIN-PIPES AND TRAPS.

All places where condensed steam can accumulate will be provided with drain-pipes and cocks or valves of ample size,

and with approved automatic traps, which will discharge into feed-tanks or condensers, or as directed. All traps will have by-pass pipes and valves for convenience of overhauling. The lowest parts of all water-pipes and all pump-cylinders and channel-ways will have drain-cocks with pipes where required. The handles of all drain-cocks will point downward when closed.

THICKNESS OF PIPES.

The thickness of metal in the principal pipes will be as follows, by B. W. G.:

Steam-pipes of 12 inches bore	No. 4
Steam-pipes of 9 inches bore	No. 5
Steam-pipes of 7½ inches bore	No. 6
Steam-pipes of 5 inches bore	No. 9
Steam-pipes of 4 inches bore	No. 10
Steam-pipes of 3 inches bore	No. 11
H. P. exhaust to I. P. cylinder	No. 4
I. P. exhaust to L. P. cylinder	No. 5
I. P. exhaust to condenser	No. 10
L. P. exhaust to condenser	No. 7
Circulating-pump suction and discharge-pipes	No. 7
Bilge-injection pipes	No. 11
Air-pump discharge to feed-tanks	No. 12
Feed-pump suction-pipes	No. 13
Feed-pipes	No. 4
Blow-pipes	No. 9
Auxiliary exhaust-pipes	No. 13
Escape-pipes	No. 13
Dry-pipes	No. 14
Connections to fire-main	No. 10
Galvanized wrought-iron bilge-suction pipes	No. 7

All pipes of which the thickness is not given in the above list will be made of approved thickness.

AUXILIARY ENGINE STOP-VALVES.

Each auxiliary engine will have stop-valves in both steam and exhaust-pipes as close to cylinders as possible. Exhaust

stop-valves will be straightway where practicable. All pumps, except circulating-pumps, will have screw check-valves in both suction and delivery-pipes close to pump-cylinders, so arranged that they may be kept off their seats when desired.

MATERIAL AND FITTING OF PIPES.

All pipes, except the lower ends of bilge-suction pipes, will be of copper, unless otherwise specified.

The lower parts of bilge-suction pipes will be of galvanized iron.

All feed and blow-pipes, all bilge-suction pipes except the lower parts, and all steam-pipes less than 3 inches in diameter will be seamless-drawn. All copper pipes not seamless-drawn will be brazed. All copper pipes over 3 inches in diameter will have composition flanges riveted on and brazed; all under 3 inches will have flanges or approved composition couplings brazed on. All feed and blow-pipes will have composition flanges. All flanges will be faced and grooved, and joints made with approved material. All composition flanges below the floor-plates will be connected by bolts and nuts of naval brass. All bends in brazed copper pipes will be one gauge thicker than straight parts. All copper pipe T-pieces and fittings will be of composition, except where otherwise directed. Expansion joints of approved pattern will be fitted where required. Slip joints, if fitted, will have stop-bolts and flanges. All copper pipes in bilges will be well painted and covered with water-proof canvas, and must not rest in contact with any of the iron or steel work of the vessel.

PUMP-CYLINDERS.

All pump-cylinders, together with their valve-boxes and fittings, will be made of composition. Air-chambers will be fitted on the delivery sides of pumps or in the pipes, as may be directed.

The water-cylinders of all vertical pumps will be so arranged that the upper head can be removed without disturbing the

framing, and the pistons will be fitted for overhauling from that end. All pumps will have either packed pistons or packed flanges.

PUMP RELIEF-VALVES.

All feed and fire-pumps will have adjustable spring relief-valves of approved design, connecting the delivery and suction passages.

SEA-VALVES.

There will be in the various compartments sea-valves, as follows:

In each engine-room a valve of sufficient size to supply water to the fire, bilge, and drainage-pump and to the auxiliary pump; also with a 3-inch nozzle for connection of the water-service pipe. This will be a screw stop-valve, and will have an independent connection to the side of the vessel. Also in each engine-room a double valve-box with a screw non-return valve for the fire and bilge-pump discharge, and a non-return valve for trap discharge. This valve-box may, if desired, be connected to the outboard nozzle of the main outboard-delivery valve. The main injection and outboard-delivery valves will be as elsewhere specified.

In each boiler compartment there will be a suction-valve of proper size to supply the auxiliary feed-pump; also a Kingston-valve for bottom blow and for pump discharge.

There will also be a sea-suction valve for the distiller circulating-pump, placed where directed..

BILGE-STRAINERS.

Each pipe leading from the bilges or from the drainage system of the vessel to the pumps, except to the circulating-pumps, will be fitted with a Macomb, or equivalant, strainer, above the floors.

ATTACHMENT OF VALVES TO HULL.

Steel strengthening-rings will be riveted to plating of hull around the openings for all sea-valves. The valve-flanges

will be bolted to these rings by naval-brass studs, care being taken not to drill the holes entirely through the rings. A zinc protecting-ring will be fitted in each opening in outer skin in such a manner as to be easily renewed.

All suction-valves will have strainers over their openings on the outside of the vessel. These strainers will have $\frac{5}{8}$-inch holes with a collective area equal to twice the area of the valve openings. Strainers must be fastened to valve-casings and not to the plates of the hull. All valves below the turn of the bilge will have pipes secured to the outer skin of hull and passing through stuffing-boxes in the inner skin.

COCKS AND VALVES.

All cocks and valves and their fittings, except as otherwise specified, will be of composition. All hand-wheels will be of finished brass, except as otherwise specified, and will be at least one and one-half times as great in diameter as their valves. All cocks communicating with vacuum spaces will have bottoms of shell cast in and have packed plugs. All cocks over 1 inch in diameter will have packed plugs.

Valves of approved pattern will be supplied wherever necessary to complete the various pipe systems, whether herein specified or not. All valves will be so fitted as to be easily ground in, and be fitted, where required, with grinding-in guides and handles. No conical-faced valve will have a bearing on its seat of more than $\frac{3}{16}$ inch in width. All valve-spindles must turn right-handed to close, and have outside threads where practicable. Cocks and valves may have, where approved, in lieu of wheels or permanent handles, removable box or socket-wrenches, marked and stowed in convenient racks. All cocks and valves underneath the floor-plates will have their wheels or handles above the floor-plates, in easily accessible positions, unless otherwise directed. The sizes of valves as given in these specifications refer to the diameters of the equivalent clear openings.

LABELS ON GEAR AND INSTRUMENTS.

All cocks will have engraved brass plates to show their uses and to indicate whether open or shut. All valves except such as may be otherwise directed will have similarly engraved plates to show their uses, or have the same plainly engraved on hand-wheels.

All hand-levers or their quadrants will be similarly marked. Gear for working valves from deck will be marked as elsewhere specified.

All main steam stop-valves will have indices to show to what extent they are opened.

All gauges, thermometers, counters, telegraph-dials, speaking-tube annunciators, and revolution-indicators will be suitably engraved to show to what they are connected.

All engraving will be deep and to be filled in with black cement.

CLOTHING AND LAGGING.

The main cylinders and valve-chests, after being finally secured in place in the vessel and tested, will be covered with approved incombustible non-conducting material and neatly lagged with black walnut all over, with polished brass bands and round-headed brass screws. The lagging will be made in removable sections over each cylinder, valve-chest, and man-hole cover, the sections to be of such size as to be easily handled, and all parts plainly marked. The lagging elsewhere be will be so secured as to be easily removed, replaced, and repaired.

All parts of the condensers except the water-chests at ends will be clothed with approved material, put on in sections so as to be easily removed and replaced.

All steam and exhaust-pipes, the separators, and all steam-valves will be clothed in an approved manner with a satisfactory non-conducting material, covered with canvas, well painted. The main steam and exhaust-pipes in engine-room and the main separators will be also covered with black-

walnut lagging with brass bands. The canvas covering of steam-pipes will be secured to bulkheads where the pipes pass through them. The main steam-pipes from the forward boilers to the port engines, where it passes through bunkers, will be, in addition to the covering above specified, inclosed in a water-tight casing of galvanized iron; likewise both main steam-pipes where they pass through the magazine compartment.

The steam-cylinders of all auxiliary engines will be clothed and lagged the same as main cylinders.

After the boilers are in place and have been tested and painted they will be covered all over, except where directed, as low as the saddles, with approved incombustible non-conducting material at least 1¼ inches thick. This clothing will be covered on tops, sides, and back heads and on fronts, where required, by galvanized wrought-iron plates about No. 18 B. W. G., lapped not less than 1 inch and bolted together; also secured to boiler-plates at bottom by angle-iron, which will be held in place by ½-inch bolts tapped part way into the boiler-plates, and held off from the boiler-plates elsewhere by suitable distance-pieces.

RADIATORS.

Radiators of approved pattern will be furnished, fitted, and connected, with areas as follows:

In the forward superstructure, two of 30 square feet each;

In the amidship superstructure, four of 25 square feet each;

In the cabin passage-way, two of 15 square feet each;

In the Admiral's cabin, one of 25 square feet;

In the commanding officer's cabin, one of 25 square feet;

In the Admiral's bath-room, one of 3 square feet;

In the commanding officer's bath-room, one of 3 square feet;

In the after compartment of the after superstructure, one of 30 square feet;

In the crew's water-closets, one of 10 square feet;

In the forward compartment of berth-deck, two of 20 square feet each;

In the 2d compartment of berth-deck, three of 25 square feet each;

In the 3d compartment of berth-deck, two of 15 square feet each;

In the 4th compartment of berth-deck, four of 20 square feet each;

In the 5th compartment of berth-deck, four of 20 square feet each;

In the sick-bay, two of 15 square feet each;

In the steerage country, four of 20 square feet each;

In the steerage, two of 15 square feet each;

In the forward ward-room, four of 20 square feet each;

In the after ward-room, two of 15 square feet each;

In the dispensary, one of 5 square feet;

In the paymaster's office, one of 5 square feet;

In the executive officer's office, one of 5 square feet;

In warrant officer's mess-room, one of 5 square feet;

In the chart-house, one of 5 square feet;

In the pilot-house, one of 5 square feet.

Each radiator or coil of more than 10 square feet will be divided into two parts. The radiators in the crew's quarters will have the valve-stems squared and fitted with removable keys.

The steam and drain-pipes will be of seamless-drawn brass, of iron-pipe size, suitably connected by composition fittings in a manner that will permit them to be easily taken down for repairs.

All union-joints will be coned or have corrugated copper washers.

All holes through decks and bulkheads will be thimbled with brass.

Steam and drain-pipes will be clothed where near wood-work.

The steam-pipes will connect with the auxiliary steam-pipes where directed, and be fitted with adjustable reducing-valves.

The drain-pipe of each circuit will have an approved automatic steam-trap discharging into feed-tank and elsewhere as directed.

Independent steam-pipes will lead from engine and fire-rooms to the principal divisions of the officers' quarters and forward parts of the ship.

WHISTLE.

An approved polished brass steam-whistle, with bell of about 8 inches diameter, will be placed forward of the forward smoke-pipe, well above the level of the awnings, and connected to the auxiliary steam-pipe by a pipe having a stop-valve at its lower end and a working-valve at the upper end. The pipe will have an expansion-joint at lower end.

SIREN.

There will be a steam-siren of approved pattern and size, placed where directed, and connected similarly to the whistle.

HOSE AND HOSE-REELS.

A sufficient length of hose will be supplied for each engine-room and each fire-room, to lead to the farthest part of the adjoining coal-bunkers below the armored deck. The hose for engine-rooms will be of the best quality rubber-lined linen, and that for fire-rooms will be the best quality four-ply rubber engine-hose; all $2\frac{1}{2}$ inches diameter, with standard couplings. Each hose will be supplied with a rubber hose-pipe with handles. A pair of spanners will be supplied for each hose.

A hose-reel of approved pattern will be fitted in each fire-room, and a swinging bracket or similar hose receptacle in each engine-room. Hose-pipes and spanners will be fitted in beckets.

SHAFTS THROUGH BULKHEADS.

All shafts passing through water-tight bulkheads will be fitted with stuffing-boxes, each in two parts.

FLOORS AND PLATFORMS.

The engine-rooms, fire-rooms, and connecting passages will be floored with wrought-iron plates ¼ inch thick, with neatly matched flat-topped corrugations running fore and aft. The plates will be of convenient size and easily removable, except such as form part of air-ducts in fire-rooms. They will rest on proper ledges of angle or T-iron, and will have drain-holes where necessary. Platforms will be provided for getting at all parts of the main and auxiliary engines and boilers. These platforms, where placed over moving machinery, will be fitted the same as the lower floors. In other places they will be made of iron rods ⅝ inch square, placed ¾ inch apart. The fire-room floors will be so arranged as to form troughs for firing the central furnaces; these troughs to be of such length as to leave a clear passage about two feet wide in the center of the fire-rooms on a level with the main floors.

LADDERS.

Ladders will be fitted wherever necessary for reaching the engine-rooms and fire-rooms from deck, and for reaching the various platforms, passages, and parts of machinery. The engine-room ladders will be made with plate-iron sides and light cast-iron treads with corrugated tops. The fire-room ladders will be made with plate sides and double square-bar treads.

All ladders will be so fitted as to be easily removable where required, and will be jointed and hinged, with necessary fastenings and gear, where they have to be moved when closing hatches. Light iron ladders will be fitted to and through one ventilator in each engine-room as means of egress when the battle-hatches are closed.

Gear will be provided for quickly opening the battle-hatches over the fire-room ladders, this gear to be worked from fire-room.

HAND-RAILS.

Hand-rails, easily removable where required, will be fitted to all ladders and platforms, around moving parts of machinery, and along bulkheads and passage-ways. The hand-rails and stanchions will be made of deoxidized bronze, or of approved equivalent metal which will not easily tarnish; and will be polished all over. The lower ends of stanchions will pass through floor-plates with nuts underneath.

GEAR FOR WORKING VALVES FROM DECK.

The safety-valves, boiler stop-valves, and engine-room stop-valves, as elsewhere specified, will have suitable gear for working them from the main deck.

The rods of the gear will be guided and supported on deck by cast composition standards, left rough and painted. Each rod will have a hand-wheel at least 3 feet above the deck. The stop-valve hand-wheels will be 16 inches in diameter, each to be fitted with an approved lock and key; all locks and keys to be alike. The wheels will be of brass, polished, and will have their rims connected with the hubs by plain discs without holes in them. Or in lieu of hand-wheels, if directed, polished brass bar-handles will be fitted to squares on the turning-rods, and will be stowed in beckets on bulkheads. The tops of rods will be protected by brass caps. All hand-wheels will be engraved with name; or cast-brass label-plates with polished raised letters will be fixed to adjoining bulkheads.

LIFTING-GEAR.

Efficient lifting-gear, consisting of traveler-bars and pulleys, deck-beam clamps, turn-buckles, shackles, hooks, eye-bolts, and as may be directed, will be fitted wherever required for lifting parts of the machinery for overhauling and repairing.

Holes will be tapped in all the principal movable parts of machinery for this purpose.

OIL-TANKS.

Oil-tanks, of 1,000 gallons total capacity, divided as directed, will be fitted where directed, with facilities for filling from deck. They will be made of wrought-iron not less than $\frac{1}{8}$ inch thick, and will each have a glass gauge, a man-hole and cover near the top, and a locked-cock for drawing oil. In each engine-room there will be fitted two copper oil-tanks of 20 gallons each and two of 8 gallons each, and in each boiler compartment one of 5 gallons, all with lock-cocks. All oil-tanks will be fitted with drip-pans.

Each of the larger oil-tanks will have a hand-pump and pipes for filling the smaller tanks.

Two iron tallow-tanks, with hinged covers, will be fitted where directed.

VENTILATORS.

Ventilators, with cowls well above the awnings, will be fitted, three to each fire-room, 24 inches internal diameter.

The ventilators will be of wrought-iron, No. 11 B. W. G., butted and single-strapped and flush-riveted. The cowls will be movable, of No. 12 B. W. G. copper, not planished, and at least 48 inches in greatest diameter. The base-rings of cowls will be of composition, finished on working parts but left unfinished on the outside. All cowls will be fitted with gear for turning them from engine and fire-rooms, the gear to be of composition except the spindles, which will be of wrought-iron. Brass hand-wheels or T-handles will be fitted to spindles in engine and fire-rooms.

TOOLS.

The following tools will be furnished in addition to those elsewhere specified:

One set of wrenches complete for each engine and each fire-room, to be fitted for all nuts in their respective compartments, plainly marked with sizes, and fitted in iron racks of approved pattern. The wrenches for nuts of bolts less than one inch in

diameter will be finished, and for all over two inches in diameter will be box-wrenches, where such can be used. Socket-wrenches will be furnished where required. Open-end wrenches will be of steel or wrought-iron, with case-hardened jaws, all others of wrought-iron or cast steel;

One pair of taps, on rod, for tapping front and back tube-sheets of main boilers at one operation. This will be a duplicate of that used in originally tapping the sheets, and be so packed as to be perfectly protected from injury;

A fixed trammel for setting the main valves without removing the covers, the valve-stems to be properly marked for this purpose;

Fixed trammels or gauges for aligning crank-shafts, brass pins being let into pillow-blocks and center-marked for this purpose;

Two complete sets of fire-tools for each fire-room;

Six coal and six ash-buckets for each fire-room.

All trammels and gauges will have protecting cases. All tools will be conveniently stowed.

DUPLICATE PIECES.

The following duplicate pieces, in addition to others specified, will be furnished, fitted and ready for use, viz:

One set of valves for each pump;

One valve-seat, with guards and bolts complete, for air-pumps;

One-half set of follower-bolts and nuts for each steam-piston, and one set for each air-pump piston;

One-half set of springs for each steam-piston;

Two bottom brasses and two top brasses for crank-shaft bearings;

Two crown brasses and two butt brasses for crank-pins;

One cap and two butt brasses for cross-head journals;

Two composition shoes complete for cross-heads;

One section of crank-shaft, to be fitted in place, and delivered at such naval station in the United States as may be directed, to be left in store;

Three blades for each propeller, fitted to propeller-bosses. These blades will be of such pattern as may be directed after the trial of the vessel;

One complete set of brasses for each main engine valve-gear;

One complete set of brasses for each circulating-pump engine, each air-pump engine, each main feed-pump, each fire-pump, and each blowing-engine;

Four spare cup-leathers for each one fitted in hydraulic gear;

One piston-rod for each piston of each pump in fire-rooms;

One feed-check valve complete;

One bottom-blow valve complete;

One complete set of metallic packing for each stuffing-box;

A spare hose and nozzle for each steam tube-cleaner;

One-eighth of a complete set of grate-bars and bearers for all furnaces, and one pattern for each casting;

Four dead-plates for furnaces and one pattern for same;

Two ash-pit dampers, with gear complete;

Two ash-pit doors;

One hundred stay-tubes for main boilers, threaded to fit threads in tube-sheets, with ends wrapped in canvas;

One hundred ordinary boiler-tubes for main boilers, swelled at one end and annealed, ready for use;

Two hundred condenser-tubes, packed in boxes;

Fifty condenser-tube glands;

One spare spring for each safety-valve and relief-valve;

One spare basket for each Macomb bilge-strainer;

One set of coils for each evaporator.

Wherever duplicate pieces are furnished for one of two or more pieces of machinery of the same size, they will be made strictly interchangeable.

All duplicate pieces, not of brass, except as otherwise specified, will be painted with three coats of white lead and oil and

Copper 6, tin 1, and zinc ¼ parts.

Naval brass—

Copper 62, tin 1, and zinc 37 per cent.

For composition not otherwise specified—

Copper 88, tin 10, and zinc 2 per cent.

Muntz metal will be of the best commercial quality.

Anti-friction metal will be of approved kind.

Ornamental brass fittings will be of good, uniform color.

All castings will be increased in thickness around core-holes. Core-holes will be tapped and core-plugs screwed in and locked, except where bolted covers are used, or where it may be directed that the holes be left open.

All steel forgings will be without welds and free from laminations.

All flanges, collars, and off-sets will have well-rounded fillets.

All boiler-plates, stays, and tubes will be well cleaned of mill-scale by pickling or other approved means.

All flanged parts of boilers will be annealed, after flanging, in an approved manner.

India-rubber valves will be of approved kind, of best commercial quality.

All bolts for securing the boiler attachments will, where possible, be screwed through the boiler-plates, with heads inside.

All work will be in every respect of the first quality and executed in a workmanlike and substantial manner.

Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.

TESTS OF MATERIAL.

All steel used in the construction of the boilers, and all steel forgings and castings will be tested in accordance with rules prescribed by the Navy Department.

All boiler and condenser-tubes will be tested to 300 pounds pressure per square inch, applied internally before being put in place.

India-rubber valves, taken at random, must stand a dry-heat test of 270° F. for one hour, and a moist-heat test of 320° F. for three hours, without injury.

TESTS OF BOILERS AND MACHINERY.

Before the boilers are painted or placed in the vessel they will be tested under a pressure of 225 pounds to the square inch above atmospheric pressure. This pressure will be obtained by the application of heat to water within the boilers, the water filling the boilers quite full.

The steam-pipes and valves, the auxiliary engines, and all fittings and connections subjected to the boiler pressure will be tested by water pressure to 225 pounds to the square inch.

The high-pressure cylinders, jackets, and valve-chests will be tested by water pressure to 200 pounds to the square inch; the intermediate cylinders and connections to 145 pounds, and the low-pressure to 100 pounds. The exhaust side of the low-pressure valve-chests will be tested to 30 pounds. The condensers will be tested to 30 pounds.

The pumps, valve-boxes, and air-vessels of the feed, fire, and bilge-pumps will be tested to 250 pounds per square inch. The cylinders and condensers will be tested before being placed on board, and must be so placed that all parts may be accessible for examination by the Inspector during the tests. All parts will also be tested after being secured on board. No lagging or covering is to be on the cylinders or condensers during the tests.

PAINTING.

After a satisfactory test the boilers will be painted on the outside with two coats of brown zinc and oil, and when in place the fronts will be painted with one coat of black paint.

All engine-work, not finished, will be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color. The shafting, when in place, will be painted with two coats of red lead and oil and two coats of black paint.

The smoke-pipes will be thoroughly painted before and after erection on board. The ventilators and cowls will be painted similarly to the smoke-pipes, except the interiors of the cowls, which will be painted vermilion.

All pipes will be painted in accordance with a schedule to be hereafter furnished.

PRELIMINARY TESTS AND TRIALS.

Steam will not be raised in the boilers until after the water-test on board, unless desired for drying or testing joints, for which purpose the pressure must not exceed 10 pounds per square inch.

After testing, steam will be raised in the boilers whenever required, to test the connections and the workings of all parts of main and auxiliary engines. All expense of such preliminary tests will be borne by the contractor.

SUPERINTENDING ENGINEER'S OFFICE.

A suitable office and drafting-room, properly furnished and heated, will be furnished by the contractor for the use of the superintending naval engineer and his assistants.

RECORD OF WEIGHTS.

The actual finished weights of all machinery, boilers, and appurtenances thereto, as fitted; also all spare machinery and tools herein specified, will be weighed by the contractor in the presence of the superintending naval engineer or one of his assistants before being placed on board; and no part of the material will be placed on board without being so weighed to the satisfaction of the superintending naval engineer.

WORKING DRAWINGS.

All drawings necessary for the prosecution of the work must be prepared by and at the expense of the contractor. Those which are developments of the drawings furnished and of these specifications will be subject to the approval of the superintending naval engineer before the material is ordered or the work commenced.

In the drawings furnished, figured dimensions, where given, will be followed, and not scale dimensions, unless otherwise directed. All discrepancies discovered in drawings, or between drawings and specifications, will be referred to the Bureau of Steam Engineering.

A copy of each working drawing will be furnished to the superintending naval engineer before the work shown by the drawing is commenced. A copy of each drawing accompanying orders for steel castings or forgings will also be supplied when the work is ordered.

Working drawings of all seatings necessary for engines, boilers, and appurtenances will be furnished by the contractor to the Navy Department, for the use of the Bureau of Construction and Repair, within sixty days after the signing of the contract.

DRAWINGS OF COMPLETED MACHINERY.

The contractor will make and furnish to the superintending naval engineer a complete set of drawings of the boilers, machinery, and appurtenances as actually completed, including plans of the same as fitted on board the vessel. These drawings will include every piece of machinery, both in whole and in part, and will be in such detail as would enable the entire machinery to be duplicated without additional drawings. No sheet will contain drawings of more than one part of the machinery, except those intimately connected with each other. The detail drawing of each part of machinery will be furnished within one month after the completion of the part without waiting for its incorporation into the machine as a whole. Detail drawings will be made to a scale of not less than one and one-half inches to the foot. General plans of the machinery in place in the vessel will be made to a scale of one-quarter of an inch to the foot. Pipe plans will be made to a scale of not less than three-eighths of an inch to the foot. The pipe plans will be divided into at least two parts—one showing steam and exhaust-pipes, and the other showing all other pipes. The pipe plans

will be colored, in accordance with a schedule to be furnished, to indicate the purpose which the pipes are intended to serve, and accompanied by an explanatory index.

All drawings will be made on the best quality of tracing-cloth, all sheets being, as far as possible, multiples or sub-multiples of "double-elephant" size.

Detail drawings will be hatched, where in section, in accordance with a schedule to be furnished, to show the various metals employed.

CHANGES IN PLANS AND SPECIFICATIONS.

The contractor will make no changes in the plans or specifications without the approval of the Navy Department. In case it is thought advisable to make changes, the contractor will make application by letter to the Bureau of Steam Engineering, through the superintending naval engineer, stating the nature of the change, accompanied by complete plans and specifications of the proposed change; together with a statement of his estimate of the amount of increase or decrease in cost.

INSPECTION.

The work of construction of the boilers, machinery, and appurtenances shall be at all times open to inspection by officers appointed for such purpose by the Navy Department. Every facility will be afforded such inspectors for the prosecution of their work. All handling of material necessary for purposes of inspection will be done at the expense of the contractor. All test specimens necessary for the determination of the strength of material used will be prepared and tested at the expense of the contractor. The contractor will furnish the superintending naval engineer with a weekly list of the number of men of each class employed upon the work, together with a statement of the number of hours labor in each class.

OMISSIONS.

The engines, boilers, uptakes, and smoke-pipes, all auxiliaries, piping, and connections, all sea-valves (except the cutting

of the holes for the same), and all parts described in these specifications and in the official drawings are to be fitted complete to the vessel by the engine contractors, and any part of the machinery, or any article pertaining thereto which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor without extra charge.