The Commonwealth of Massachusetts, by an act of Legislature, appropriated \$50,000 to pay for the hospital ship. The State of Massachusetts held the deed, and the ship was placed at the disposal of the Volunteer Aid Association to equip. The construction and equipment of the vessel will be presented by others.

CONSTRUCTION OF MASSACHUSETTS HOSPITAL SHIP "BAY STATE."

BY MR. J. T. BOYD, BOSTON,
Consulting Engineer.

In fitting out the *Bay State*, the work was directly under the charge of the Board of Control, — Major

The berthing details were decided by Dr. Bradford, Professor Hollis and myself. Dr. Manahan assisted in the arrangement of these wards very much.

The storerooms, clinical laboratory, apothecary storeroom and storerooms for surgical apparatus were arranged by the doctors who had charge of these different departments.

The general arrangement of the ventilating, lighting, water system I arranged in consultation with Professor Hollis.

The arrangement and detail of water-closets were discussed by almost every one, and finally settled by Dr. Burrell and myself.

The very best feeling prevailed while this work was in progress, and there was no clashing, which, I think,

FIG. 9. Forward ward, showing three tiers of berths, with berths corded, beds made up, toilet bags and wash-basin in position.

Henry L. Higginson, Mr. Robert Burnett and Dr. Burrell, — receiving the immediate oversight of Mr. Burnett and Dr. Burrell, and, in the absence of Dr. Burrell, of Dr. Bradford, Dr. Manahan being the resident doctor at the works, and the principal assistant in deciding on the work.

The ice machinery was ordered by Mr. Robert Burnett, and I think, without question, is one of the best small plants that has ever been fitted in a vessel.

The sterilizer for the bedding, etc., was ordered by Dr. Durgin, and proved a success.

The fitting out of the operating-room, both in general lay-out and in detail, was the work of Dr. Bradford and Dr. Manahan.

The laundry machinery was decided on by Dr. Manahan.

is one of the principal reasons why the work was done so quickly and so well.

For comparison I give the dimensions of three steamers fitted as hospital ships by the United States :

Creole. — Crowell Line. Constructed of steel. 358 feet long, 44 feet beam, 24 feet deep. Engines, 28", 44", 74" x 54" stroke. Built in 1896 by Newport News Ship Building Co. Gross tonnage, 3,801; net tonnage, 2,622. Fitted as a hospital ship for the United States Navy, and named the *Solace*.

John Englis. — Maine S. S. Co. Constructed of steel. 290 feet 8 inches long, 46 feet beam, 21 feet deep. Built in 1896 by the Delaware River Iron Ship Building and Engine Works. Gross tonnage, 3,095; net tonnage, 1,987. Fitted as a hospital ship for the United States Army and named the *Relief*.

Olivette. — Plant S. S. Co. Constructed of iron. 274 feet 3 inches long, 35 feet 2 inches beam, 11 feet 9 inches deep. Built in 1887 by Wm. Cramp & Sons Ship & Engine

¹ Read before the Boston Society for Medical Improvement, November 21, 1898.

Building Co. Gross tonnage, 1,611; net tonnage, 1,105. Red Cross hospital ship.

What is known as the gross registered tonnage of a vessel is the internal capacity in cubic feet divided by 100. The net registered tonnage is the capacity less the cubic space occupied by the engines, boilers, coal bunkers, etc.

HOSPITAL SHIP "BAY STATE." (FIG. 1.)

The steamship *Bowden*, afterwards *Marmion*, was built by Scott & Co., of Bowling, Scotland, in 1886, and was used in the fruit business between Jamaica and Boston until purchased by the Massachusetts Volunteer Aid Association, by whom her name was changed to *Bay State*. The general dimensions of the ship are: Length, 200 feet; beam, 27 feet; depth, twelve feet, seven inches; gross tonnage, 776; net, 388. She had cabin accommodations for a few pas-

water-closets and one sink for this ward are located on port side, forward end. One bath-tub and two wash-bowls are located on centre line of ship near after end of the ward.

The after ward extends from bulkhead aft of engine-room to extreme stern of vessel; length about 68 feet; average width 24 feet; fitted for berthing fifty patients when two frames are used to a section. Four additional frames were placed in the extreme end known as the lazarette. Three water-closets and two sinks are located on port side; the bulkhead for isolated ward divides the water-closet room, so that one closet and one sink comes in isolated ward. The isolated ward bulkhead is about 48 feet aft of engine-room bulkhead with openings at port and starboard sides which can be closed with plates. This ward has space for 18 patients.

FIG. 10. Aft ward, three tier construction, mess table and entrance to cold storage.

sengers. In fitting for a hospital ship the vessel was first cleaned thoroughly; the ballast, which consisted of granite blocks, was removed, the ceiling taken up, and the iron work of hull, both inside and outside, chipped, cleaned and painted. New ballast of pig-iron was put in, the old ceiling was thrown away and new fitted. The main deck, now termed the hospital deck, was smoothed up and sheathed with seven-eighths-inch tongued and grooved stock forward and aft of engine and boiler space. This deck was painted. After the first trip the passageways were covered with ribbed rubber. At sides of engine and boiler-bulkheads the iron deck was covered with cement and asphalt.

The forward ward extends from bulkhead forward of boiler space to bulkhead at forecastle; length about 66 feet; average width 24 feet; fitted for berthing 50 patients when two frames are used to a section. Two

The starboard side of deck between the wards is fitted with four staterooms for baymen. The passageway connecting wards is of sufficient width to allow for transfer of patients. The port side is fitted with operating-room, sterilizing-room and laundry. The laundry has door opening from the after ward. The sterilizing-room is entered through the laundry. Materials to be sterilized can also be put into the room from an opening in the deck, which is closed by a water-tight plate. The operating-room is entered from the forward ward.

The forward lower hold contains the coal bunkers for main boiler. From coal bunker forward, the hold is divided by a deck about nine feet below the hospital deck, called the orlop deck. Below this deck is fitted storerooms for ship stores. These rooms are built of wood slabs with about one inch spacing, fitted

with doors. Openings to passageway between these storerooms are through hatches in the orlop deck.

The orlop deck is divided with substantial wire netting into rooms for apothecary stores, clinical laboratory, surgical apparatus, linen stores, room for storing clothing belonging to patients, and the remainder fitted with frames for 20 patients.

The after lower hold is fitted with ice-making machinery, cold-storage rooms, ice tanks, ice-room, and fresh-water tanks. The ice-making machinery is separated from the rest of the hold by steel bulkheads, and the entrance to it is through the engine-room. This machinery was furnished by the Hendrick Manufacturing Company of Carbondale, Pa., of the type where the brine is cooled and taken from the cooler through the brine tanks. By this process no ammonia is taken outside of the space allowed for the

house on this deck contains five staterooms, two pantries, a cabin and a water-closet. Three of the five staterooms were used by the female nurses.

The pilot house and captain's room are on the bridge deck, which extends from forward end of forward house to stern of vessel. A strong galvanized rail with awning stanchions is fitted on this deck. Hatches are arranged over the hatches to the wards so that patients can be lifted from the hospital wards to the deck. Attached to the beams are hammock hooks for swinging hammocks. There is an awning to cover this entire upper deck. (Fig. 3.)

Sanitary Arrangements. — The waterways at sides of wards are cemented. Scuppers, 4 inches diameter, are fitted. All water-closets are of the Hercules type with tanks for flushing. (Fig. 4.) The closets are placed so that soil pipes lead through side of ship above water

FIG. 11. Isolated ward, two tier construction, bulkhead which can be put up shutting off ward from rest of ship.

machinery, making thereby one of the best plants for ship use.

The forecabin is fitted with iron berthing frames for the men, and with two mess tables. Berthing capacity for eighteen men.

The upper or main deck has steel deck-house forward containing six rooms. These rooms were occupied by the doctors and two of the engineers. On the port side forward of this house are two water-closets enclosed in a small steel house, which house also contains space for oils, paints, etc.

The main deck-house, which also covers the engine and boiler space, contains the first and second mates' room, two bath-rooms — one fitted with bath-tub, and one with shower-bath — with floors of asphalt. At the aft end of this house is the galley with dumb-waiter connecting with hospital ward. (Fig. 2.) The aft

line, and are fitted with storm valves. The water service is from a pump which runs continuously, the overflow from tanks flowing through the closets. The baths are arranged with Gegenstrom heaters except the shower-bath. All plumbing is open.

Ventilation. — A large blower is located in upper engine-room. The suction pipes extend through the after and forward wards, with branch to lower between decks forward. Openings in pipes are covered with wire netting, and dampers are fitted to regulate the draught. The air is changed very rapidly. The discharge pipe extends up through engine-room skylight with delivery some distance above bridge deck.

The ice-machine room is ventilated by a pressure fan, outlet pipes running through upper and bridge decks.

About fifty-four electric fans are located throughout the wards, and one in each stateroom.

Hatches.—The hatch openings on main deck have iron frames with canvas covers, which are to be used in heavy rain storms. Hatch covers of wood are fitted so that in case of a violent storm they can be put in and battened down.

Lighting.—A direct connected engine and dynamo are located in the lower engine-room. The vessel is wired throughout. There are about one hundred and fifty lights. The fittings for lights are the same as for electric fans.

Fire Service.—Connection on deck from single pump, and outlets on water service pipes with hose to reach to any part of vessel.

General.—Vessel is fitted with steam windlass and steam steering gear, one alco-vapor launch, four life-boats, two rafts, and about one hundred and seventy life preservers.

The details of construction are all carefully worked out. All berth frames are of one size, 24 by 74

AUXILIARY MACHINERY.

Pumps.—Bilge and ballast pump, Knowles duplex, $7\frac{1}{2}$ " x $4\frac{1}{2}$ " x 10". Deck and fire pump, Knowles single, $7\frac{1}{2}$ " x $4\frac{1}{2}$ " x 7". Distiller circulating, Blake duplex, $5\frac{1}{2}$ " x $5\frac{1}{2}$ " x 6". Donkey feed pump, Blake single, $7\frac{1}{2}$ " x $4\frac{1}{2}$ " x 10". Fresh water distributing, Blake single, $6\frac{1}{2}$ " x $4\frac{1}{2}$ " x 8". Evaporator feed pump, Blake single, $3\frac{1}{2}$ " x $1\frac{1}{2}$ " x 3". Ice-machine circulating, Blake special duplex, $6\frac{1}{2}$ " x $5\frac{1}{2}$ " x 6". Ice-machine brine, Deane duplex, $6\frac{1}{2}$ " x $5\frac{1}{2}$ " x 6".

Dynamo and Engine.—Sturtevant type, direct connected. Engine $5\frac{1}{2}$ " x $4\frac{1}{2}$ " double vertical, 575 R. P. M. Dynamo multipolar 12,000 Watts at 110 volts.

Evaporator and Distiller Plant.—James Reilly Repair and Supply Co. Capacity 3,000 gallons in twenty-four hours.

Ventilating Fans.—One 70" exhaust fan, Sturtevant, for ward ventilation. One 40" pressure fan, Sturtevant, for ice-machine room ventilation.

Ice Machine.—Capacity 5 tons in twenty-four hours. Engine cylinder, single, $10\frac{1}{2}$ " diameter x 15" stroke. Compressor cylinder, single, $7\frac{1}{2}$ " diameter x 15" stroke.

Coal capacity, 166 tons.

Draught loaded, 9' forward, 13' 8" aft.

Tanks, Fresh Water.—Fore-peak supply and trimming tank, 8,000 gallons capacity. After-peak supply and trimming tank, 2,500 gallons capacity. Two supply tanks in after hold, total 2,300 gallons capacity. One pressure tank for running water head, 250 gallons capacity. Ballast tank bottom from aft engine-room bulkhead, 48 tons capacity.

Tanks, Oil.—One tank for vapor launch supply, 210 gallons. Three engine supply tanks, 68, 68 and 55, 171 gallons. (Fig. 5.)

Sterilizing Machine for Bedding, etc.—4' 6" diameter x 6' 6" long.

FIG. 12. Operating-room.

inches, and are interchangeable. The substitutes for side boards for berths are rods clamped to standards by a yoke. The serving tables are conveniently located in the wards, as are also the closets for linen, etc. The inside and outside of vessel received several coats of paint, and the final coats in wards were of enamel white.

There are side ports at main deck, two on starboard and two on port side, through which patients can be brought on board or taken ashore directly from the wards.

Appended are memoranda giving general dimensions of vessel, sizes of engines, etc.:

Principal Dimensions of Hull.—Length between perpendiculars 199.5 feet. Breadth, extreme, 27.1 feet. Depth 19.8 feet. Tonnage, measurement—gross 776.60; net 388.30.

Main Engines.—Two, $32\frac{1}{2}$ " x $53\frac{1}{2}$ " diameter of cylinder by 36" stroke.

Main Boilers.—Two, Scotch type, $11\frac{1}{2}$ " x 10' long. Two 36" furnaces in each boiler; 143 pounds steam.

Auxiliary or Donkey Boiler.—One upright tubular, 60" inside diameter, 9' high, $5\frac{1}{2}$ " diameter furnace of 150 pounds steam pressure.

Windlass.—No. 4 Hyde 6" x 8", double engines.

LAUNDRY MACHINERY. (FIG. 6.)

One 4" x 4" steam engine. One wooden machine 22" diameter, 26" long, rev. 160. One power wringer, rolls, $3\frac{1}{2}$ " diameter, 16" long.

MEDICAL EQUIPMENT.¹

BY E. H. BRADFORD, M.D., BOSTON.

THE equipment of the hospital ship *Bay State* was planned with the idea that she should be ready for whatever emergency the chances of war might bring, with the chief idea, however, that she should serve as a hospital transport for the transferring of the sick to mainland hospitals and with preparations only for short trips. As she was visiting a country where yellow fever was to be expected, it was necessary that her construction should be such that it could be easily and thoroughly cleaned and fumigated. Wood con-

¹ Read before the Boston Society for Medical Improvement, November 21, 1898.