Reprinted from RCA REVIEW, *October, 1940*

SS "AMERICA" RADIO INSTALLATION

BY

I. F. BYRNES

Chief Engineer, Radiomarine Corporation of America, New York

THE largest and fastest passenger liner built in the United States up to the present time is the new S.S. *America.* This vessel (Figure 1), which is owned by the United States Lines Company, was placed in commercial service in August of this year. The *America* is a 35,000-ton ship and has a length of 723 feet, a beam of 93 feet and is designed to carry approximately 1200 passengers. The radio installation is specially designed to provide the utmost in safety and communication efficiency and in all respects is in keeping with the modern design features of the vessel itself. The radio room is located near the forward section of the sports deck, and is in close proximity to the bridge and chart room.

Fig. 1

ANTENNA SYSTEM

A fairly elaborate antenna system is provided on the *America* in order to accommodate the various radio transmitters and receivers which must operate over wide frequency bands for both telegraph and telephone service. The main flat-top transmitting antenna is divided into two sections, and consists of a single wire supported between the foremast and the mainmast. The aft flat-top section is approximately

240 feet long, while the forward section is 60 feet long. The flat-top is divided with insulators directly above the radio room, and two 70-foot downleads are brought into the trunk, as shown in Figure 2. By means of switches in the radio room, the larger flat-top section may be used

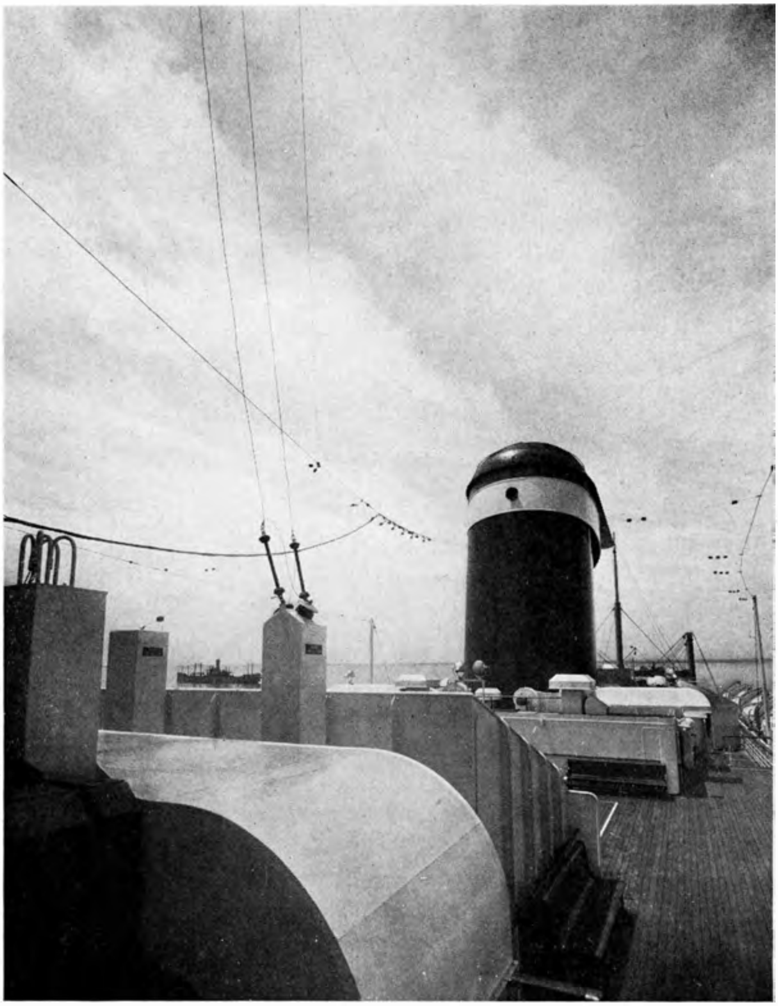

Fig. 2

for the intermediate-frequency transmitter and the forward section for high-frequency telephone or telegraph operation. Both flat-top sections may be connected in parallel for low-frequency or long-wave transmission. The main transmitting antenna is approximately 107 feet above the water line. The effective capacity of the aft section is about 1000

$\mu\mu f$, while the forward section has a capacity of approximately 500 $\mu\mu f$.

There are five doublet antennas, for high-frequency reception, located between the stacks and supported in the thwartship plane of the vessel. These doublets are cut for various frequencies between 4 and 22 megacycles. In addition, there is also provided a horizontal "V" antenna which may be used with the emergency transmitter or the high-frequency telegraph transmitter.

Fig. 3

Radio Room Transmitters

The four main transmitters in the radio room are shown in Figure 3. These transmitters, while differing considerably in electrical design, are built in frames of equal size in order to permit a symmetrical layout and uniform appearance. The transmitter on the right is for low-frequency radiotelegraph service, and is designed to deliver one kilowatt of power to the antenna on any one of ten crystal-controlled frequencies between 110 and 160 kilocycles. The next transmitter is for intermediate-frequency service, and provides ten crystal-controlled frequencies and one kilowatt of antenna power in the band from 350 to 500 kilocycles. The third unit, for high-frequency radiotelegraph transmission, covers five frequency bands between 4140 and

22,200 kilocycles, with provision for a maximum of thirty crystal-controlled output frequencies and one kilowatt of antenna power. The fourth transmitter is the radio-frequency unit for the 600-watt radiotelephone transmitter. This is a five-band transmitter, crystal-controlled, and is normally set up for the ship-to-shore telephone bands between 4000 and 18,000 kilocycles. Additional details on the construction of these transmitters is considered further in this paper.

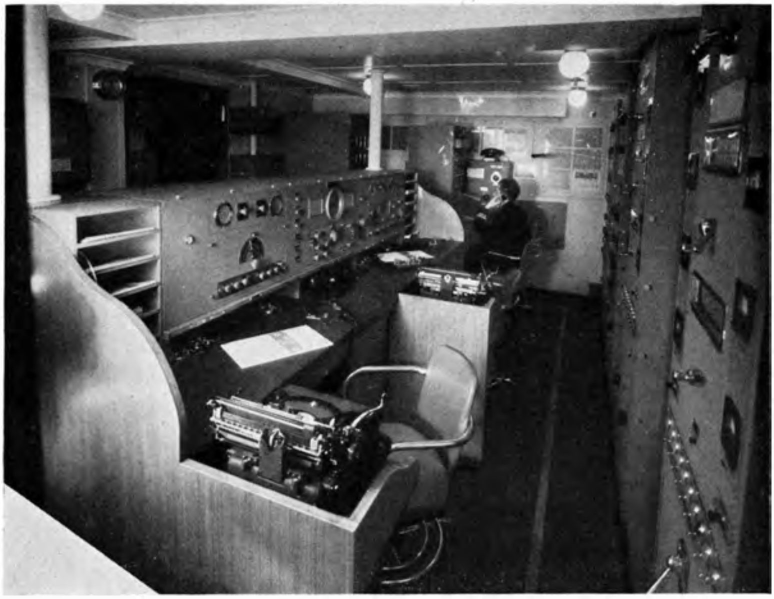

Fig. 4

Radio Room Receivers

For radiotelegraph reception, a special receiver console was designed as an integral part of the radio operating position in order to provide the most efficient and convenient facilities for the radio operators. This arrangement is shown in Figure 4. The radio receiver to the left is a superheterodyne unit covering a band from 75 to 1500 kilocycles. The receiver unit in the center of the console, directly beneath the radio room clock, is employed for general stand-by or auxiliary service and is a tuned radio-frequency unit covering the band from 15 to 600 kilocycles. The third receiver at the right end of the console is used for high-frequency reception, and is a superheterodyne covering all frequencies between 540 and 30,000 kilocycles. All receivers are arranged for both loud-speaker and headphone reception, and with switching facilities to enable time signals to be passed on to a loudspeaker located in the chart room. The receiver console is also provided with the necessary control switches for the radio transmitters. In the far end of the radio room, there is located the radiotelephone operator's position, which includes the operator's control panel, radiotelephone receiver and the radiotelephone rectifier-modulator unit. The control panel provides circuits for connection to the radiotelephone booth located just outside the radio room, and in addition is arranged for connection to stateroom telephones.

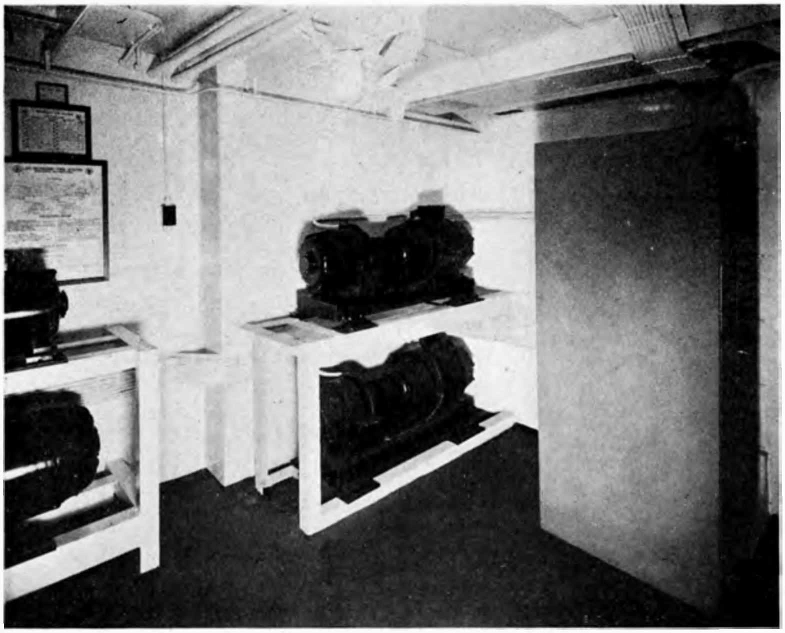

Fig. 5

Power Supply

While a small amount of 60-cycle power supply is available on the *America*, the principal power source is 230 volts d.c. For this reason it was necessary to use rotating equipment in order to provide the necessary voltages for the four main radio transmitters. In shipboard radiotelegraph service, an important consideration is to provide facilities to enable the radio operator to go "on the air" in the shortest possible time. This factor makes it undesirable to employ mercury vapor rectifier tubes or other types of tubes which may require thirty seconds or more time delay before reaching their operating temperature. For these reasons, it was decided to employ high-voltage d-c motor generator sets for plate supply, and to use filament type tubes in the radio transmitters. With such an arrangement, any of the radiotelegraph transmitters may be placed "on the air" within

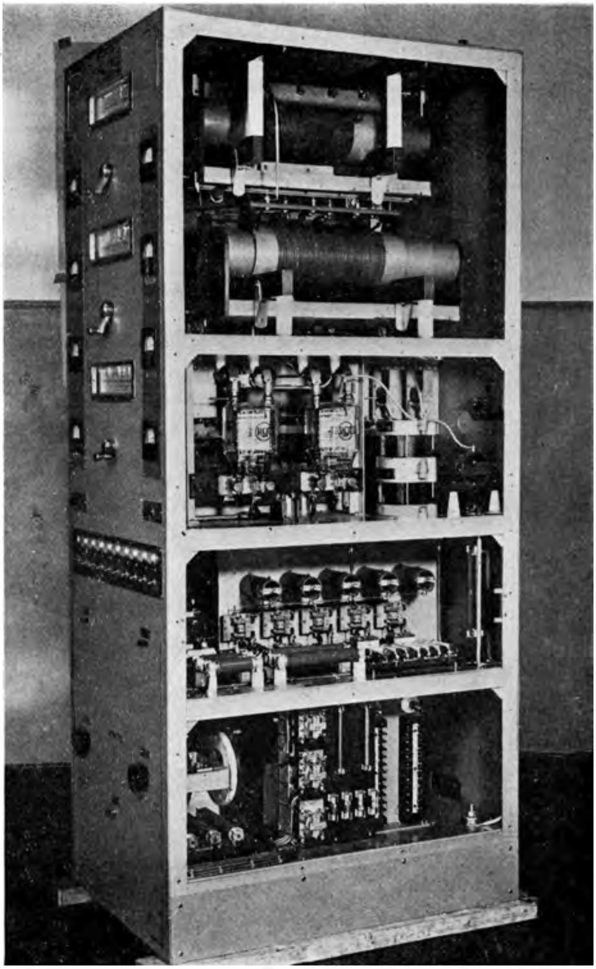

Fig. 6

approximately three seconds. The high-voltage motor generators and their control panel are located in the fire control room just aft of the chart room. These machines and the "starter-filter panel" are shown in Figure 5. There are two 2500-volt motor generator units, one of which is used to supply power to either the intermediate- or low-frequency transmitter, while the second high-voltage machine supplies the one-kilowatt high-frequency telegraph transmitter. Provision is made in the "starter-filter panel" to switch the high-frequency motor generator so that it may be used to furnish power to the intermediate or low-frequency transmitters in the event of machine failure. The

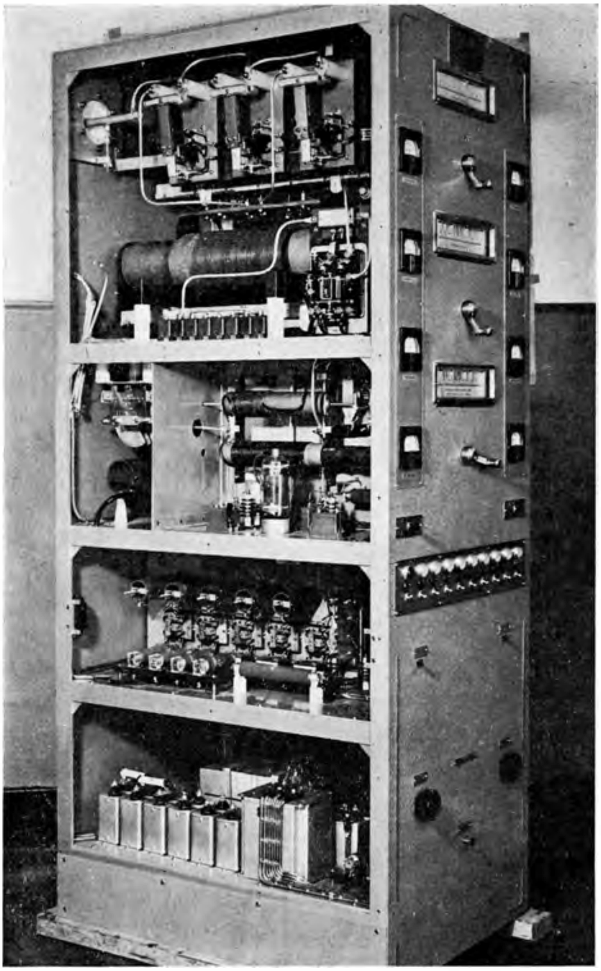

Fig. 7

third motor generator in the fire-control room furnishes 625-cycle power for modulating the intermediate-frequency radiotelegraph transmitter. The fourth machine is a standard motor alternator unit, and supplies 60-cycle power for the 600-watt radiotelephone equipment.

Transmitter Design

A view of the interior construction of the one kilowatt intermediate-frequency transmitter is shown in Figures 6 and 7. The transmitter employs only four tubes. The crystal oscillator stage consists of a 1624 pentode, and is arranged with ten pre-tuned oscillator circuits, the tuning adjustment being obtained by means of movable iron cores. Small relays, controlled by toggle switches on the front panel, enable the appropriate crystal and oscillator circuit to be quickly selected. The buffer stage of the transmitter consists of an 813 tube, and the power amplifier stage uses two 833 tubes which operate in parallel. For the so-called "working" waves, that is, all frequencies in the intermediate band except 500 kilocycles, there are provided ganged buffer and power amplifier tuned tank circuits which are controlled from the front panel. Movable iron cores are used here for inductance variation. In like manner, the antenna circuit may be resonated to any one of the working frequencies by means of a panel control which moves the iron cores in or out of the antenna loading inductance.

The international distress and calling frequency of 500 kilocycles is pre-tuned throughout in the intermediate-frequency transmitter, and relays are provided in the various stages to instantly connect the 500-kc channel to the antenna. By means of this arrangement, the radio operator need only throw a small switch, from his operating position, in order to change from 500 kilocycles to any one working wave that he has previously selected. This facility enables expeditious handling of traffic and eliminates the need on the part of the operator to manipulate controls on the radio transmitter when he wishes to change from the calling to a working frequency or vice versa.

The intermediate-frequency radiotelegraph transmitter must be designed for both A-1 (continuous wave) and A-2 (modulated wave) emission. In the *America's* transmitter, modulation is accomplished by means of a 625-cycle alternator which is coupled to the plate circuit of the radio power amplifier tubes through a suitable step-up transformer. About 750 watts of audio power are required to modulate the carrier at 80 per cent modulation. Suitable precautions have to be taken to insulate the antenna loading inductances as well as the relays in the antenna circuit of the transmitter, since peak voltages to the order of 17,000 volts are developed in the output circuit. The antenna current on A-2 transmission is approximately 22 amperes.

The design of the low-frequency (110-160 kilocycles) transmitter is in general similar to that employed for the intermediate-frequency set. The low-frequency transmitter is arranged for A-1 emission only, as modulated wave transmission is not permitted in this band. A power transfer switch is used on the low-frequency set so that the high-voltage motor generator may be readily connected to this set or to the intermediate-frequency transmitter. Both transmitters are never used simultaneously, and for this reason it is possible to operate with the same motor generator power supply and the same antenna system. Since a large value of CL is required for operation around 110 kilocycles, it is desirable to have an antenna of the highest possible

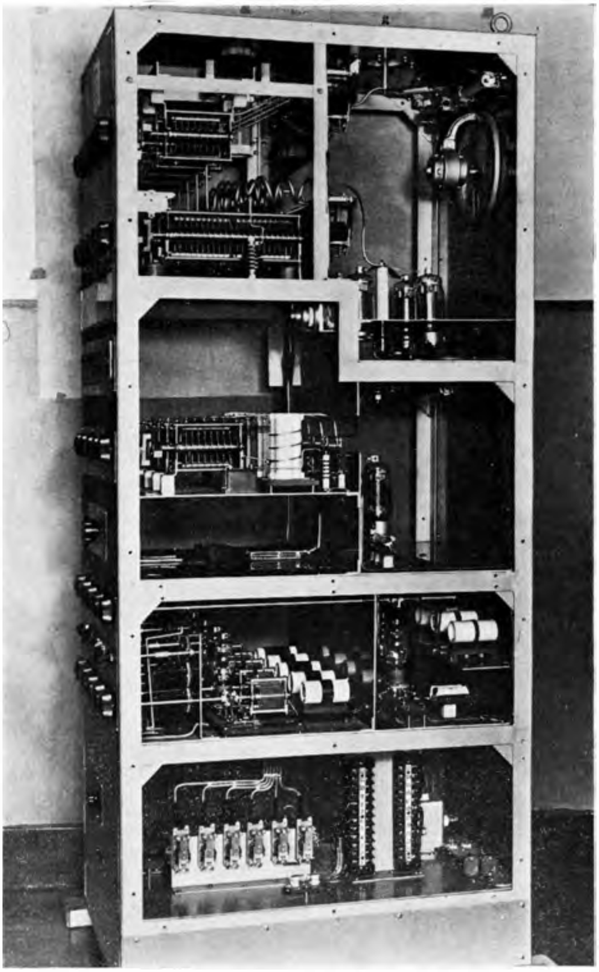

Fig. 8

effective capacitance in order that the necessary antenna loading inductance may be kept down to as low a value as possible. This is accomplished on the *America* by paralleling the forward and aft sections of the main flat-top. Voltages to the order of 25,000 volts exist at the antenna output terminal of the low-frequency transmitter.

For high-frequency telephone or telegraph transmission, the design of the transmitters follows conventional practice with the exception that provision is made for pre-tuned circuits throughout in each of the high-frequency bands. An interior view of the radio-frequency unit of the 600-watt telephone transmitter is shown in Figure 8. Separate oscillator and buffer amplifier tubes are used for each of the five bands between 4000 and 18,000 kilocycles. Type 807 tubes are used in each of these stages. The third stage, which functions as a fundamental amplifier or as a frequency multiplier, is a Type 813 tube, while the final power amplifier stage consists of four Type 813 tubes operating in parallel. Relays, operated either from the front panel or from the operator's position, enable the various pre-tuned stages to be instantly selected. If the operator requires a different frequency in any one band, he selects the appropriate crystal from the transmitter panel. This arrangement therefore provides a total of five "quick" frequencies within the entire range. As each band has facilities for six crystals, it is possible to use the transmitter on a total of thirty output frequencies.

The power amplifier stage of the 600-watt telephone set is plate modulated with power derived from a separate "rectifier-modulator" unit. This unit comprises four Type 805 modulator tubes which function as Push-Pull Class "B" amplifiers. These tubes are preceded by conventional stages of Class "A" audio amplifiers, finally terminating in the output of the microphone. A separate audio amplifier-rectifier unit, operating from the microphone output, is employed to permit voice control of the transmitter carrier wave. This arrangement, in effect, keys the transmitter unit each time speech is impressed on the microphone and at the same time renders the radio receiver inoperative. When the party aboard ship stops talking, the transmitter carrier is cut off and the receiver input and output circuits are energized. Operation with voice-controlled carrier is of considerable value when receiving signals under unfavorable conditions, as it eliminates the necessity of the ship's radio receiver being required to work through the strong outgoing signal from the transmitter. Under more favorable receiving conditions, it is preferable to operate with a constant carrier, and when connections are made to staterooms, because this eliminates "clipping" of initial speech syllables and more nearly simulates land-line telephone operation. The control unit for the telephone transmitter is fitted with a privacy device to invert outgoing speech, as well as to restore the incoming inverted received signal.

The high-frequency radiotelegraph transmitter unit is designed similarly to that employed for telephone, except that A-1 emission only, with an antenna power of one kilowatt, is provided. In addition, the high-frequency telegraph transmitter provides operation in the 21,000-kilocycle ship telegraph band.

Emergency Equipment

Passenger vessels are required by law to be equipped with a separate emergency transmitter and receiver, energized from a separate power supply so that operation for a period of at least six hours may be obtained independently of the ship's normal power source. On the *America,* a completely separate emergency station is installed in one

Fig. 9

corner of the main radio room. This layout is shown in Figure 9. A small 50-watt transmitter, which derives its power from a motor generator set, and a large 12-volt storage battery, is employed. A standard shipboard 15-600 kilocycle intermediate-frequency receiver and an auxiliary crystal receiver are also installed. An auto alarm, mounted on the bulkhead, for standing a distress watch on 500 kilocycles is provided as a further aid to safety to permit reception of the international alarm signal in the event that the radio operators are engaged in handling traffic on other frequencies.

Auxiliary Radiotelephone

A noteworthy feature of the radio installation of the *America* is the coastal harbor type of radiotelephone transmitter and receiver that is installed in the radio room. This is a ten-frequency 75-watt crystal-controlled transmitter and a ten-frequency receiver, which operates in the coastal harbor band between 2000 and 3000 kilocycles. This equip-

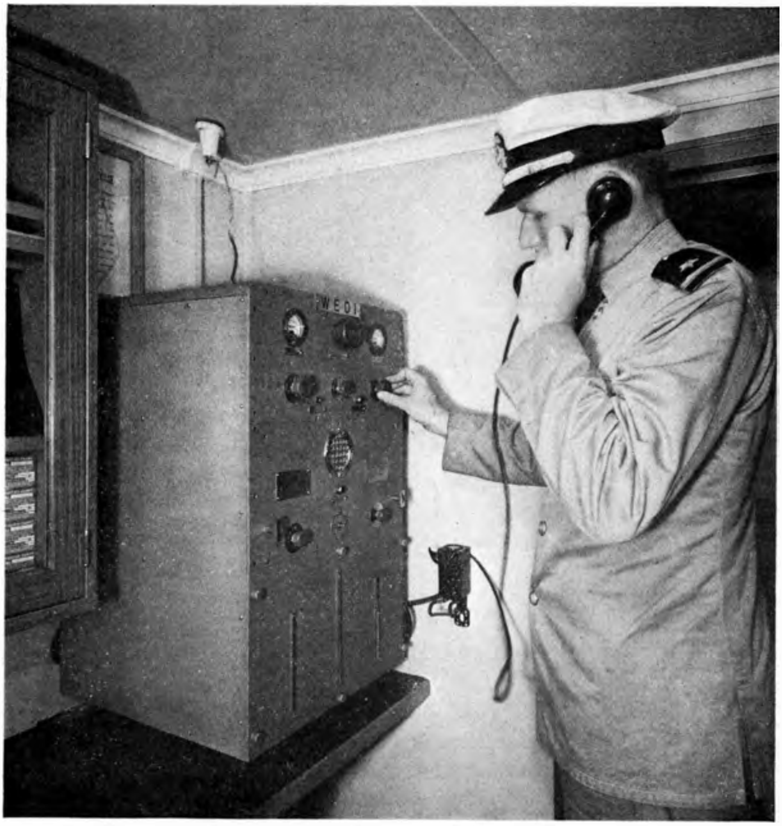

Fig. 10

ment is shown in Figure 10. The auxiliary radiotelephone provides a convenient means of communication with tugboats or coastal stations when approaching port.

Radio Direction Finder

A modern direction finder is installed on the bridge of the *America*, as shown in Figure 11. This instrument employs a highly sensitive and selective superheterodyne receiver, and is employed in the conventional manner for taking bearings on marine beacon stations or on other vessels. The main compass card of the direction finder is driven by the vessel's gyro repeater system, thereby enabling great circle radio bearings to be obtained with respect to true north.

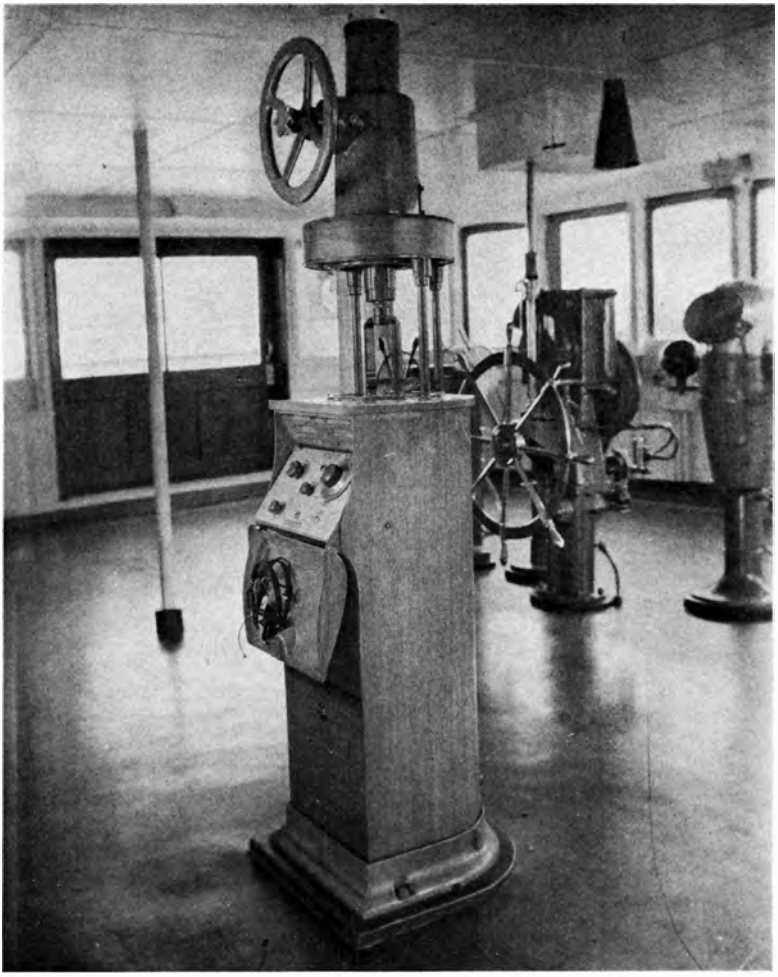

Fig. 11

Lifeboat Radio

The port and starboard motor lifeboats of the *America* are each completely equipped with a radiotelegraph installation to comply with Government Regulations. The radio transmitter in each lifeboat is pretuned to 500 kilocycles, while the radio receiver covers the conventional intermediate-frequency band of 350-500 kilocycles. Each motor lifeboat is fitted with a large 12-volt storage battery which operates the radio transmitter and receiver for a period of at least six hours. The antenna available on the lifeboats is necessarily small, and consists of a single wire approximately twenty feet long and twenty feet above the waterline. The masts for the antenna are hinged so that they may be readily stowed when the lifeboats are on the davits. The storage batteries in the lifeboats are maintained on continuous charge by means of suitable charging panels located in the radio room.

MISCELLANEOUS

A total of 122 vacuum tubes are used in all of the radio equipment on the *America*. The maximum current required from the ship's main 230-volt d-c line is approximately 85 amperes. About 95 leaded and armored conductors, with a total weight of 4½ tons, are required for the various incoming and outgoing circuits of the radio room. The total weight of the radio transmitter, receivers, motor generators, etc., is 6½ tons.

For the convenience of passengers, there is available a small reception room adjacent to the main radio room and near one of the elevators on the vessel. The reception room includes a sound-proofed telephone booth for the ship-to-shore telephone service. Under normal conditions, simultaneous operation of two telegraph transmitters, the main telephone set and the auxiliary radiotelephone may be accomplished.

Printed in U.S.A.