MARINE HEATING & VENTILATING

Cruiser HMS Terrible 1895, 14,200 tons, 500 x 71 feet

The text is from the American magazine "Heating, Piping & Air Conditioning," October 1944

00183

Ref. Items 1923 1934-39. (12)

Years of Progress in Ship Ventilation and Heating 1893-1943†

17

By John W. Markert*, Washington, D. C.

THE 50-YEAR period between 1893 and 1943 produced many entirely new methods and extensive applications of ventilation and heating in all types of ships.

Natural ventilation by means of cowls, skylights, and airports was generally used for ship ventilation previous to 1893, while stoves, hot water and steam pipe coils were commonly used for heating. The ventilation systems of the *Oceana* and *Arcadia* of the P and O Co. (1885) were exceptions, as these vessels were provided with a combined plenum and vacuum system, in which *jets of compressed air at 4 psi* were used to induce air flow in the ducts. This arrangement was considered much more effective than that in two similar vessels equipped with a vacuum system, in which the vacuum was produced by a reciprocating vacuum pump.

The paddle steamer *Princess May* (1892) was another exception, because *mechanical ventilation* was provided by steam engine driven fans for the cattle spaces. This vessel was also unusual in that heating by means of *steam pipe coil radiators* was provided for steerage and crews' quarters as well as for the saloons.

The record shows that the U. S. Coastline Battleship *Indiana* (1893) had a "thorough system of ventilation, and air could be forced into or drawn out of any part of the vessel by steam-driven fans." While it is not clear just what system was employed to achieve this ventilation, it should be noted that the so-called *American* system of heating and ventilating used at that time consisted of a supply fan which discharged the air into foyers and passageways from which the air flowed into the staterooms via louvers. Either natural or mechanical ventilation was provided to extract the vitiated air directly from the staterooms. Heating was accomplished by blast coils consisting of steam heated pipes installed in the ducts. Among the first passenger ships to have this system of ventilating and heating, and employing motor-driven fans, were the *St. Louis* and *St. Paul* of the American Line (1895).

One of the earliest efforts in *sound proofing* was probably that made in the Cunard Twin-Screw Steamer, *Compania* (1893), which had a double casing around the machinery space *filled with material to reduce heat and sound.*

In 1893 W. Tattersall, Accrington, Lancashire, England, patented a propeller fan, which had four bucket type blades, and was not self-propelled. This type of fan (electrically driven) was first used on the Union Line Twin-Screw Steamer, *Norman*, in 1894, for exhausting air from passageways and public rooms into the stokeholds. In this ship the drawing room was *air-cooled* by circulating cooled brine through the hot blast heating coils.

The introduction of tankers presented a new application for ventilation. In 1894 a system was patented which ventilated the oil tanks by means of the cargo oil lines through which steam-driven fans supplied 2000 cfm of air at 16 in. pressure.

Prior to 1894, *fans were driven by steam engines.* The introduction of electricity into ships caused a rapid change to motor-driven fans so that by 1895 they were rather common, except in forced draft equipment. Some designers preferred to retain the steam engines because the exhaust steam could be used in the hot blast coils. Motor-driven fans were used by the U. S. Navy in 1895.

The cruiser, *Terrible* (1895), was probably the first British warship provided with mechanical supply ventilation to all spaces below the protective deck.

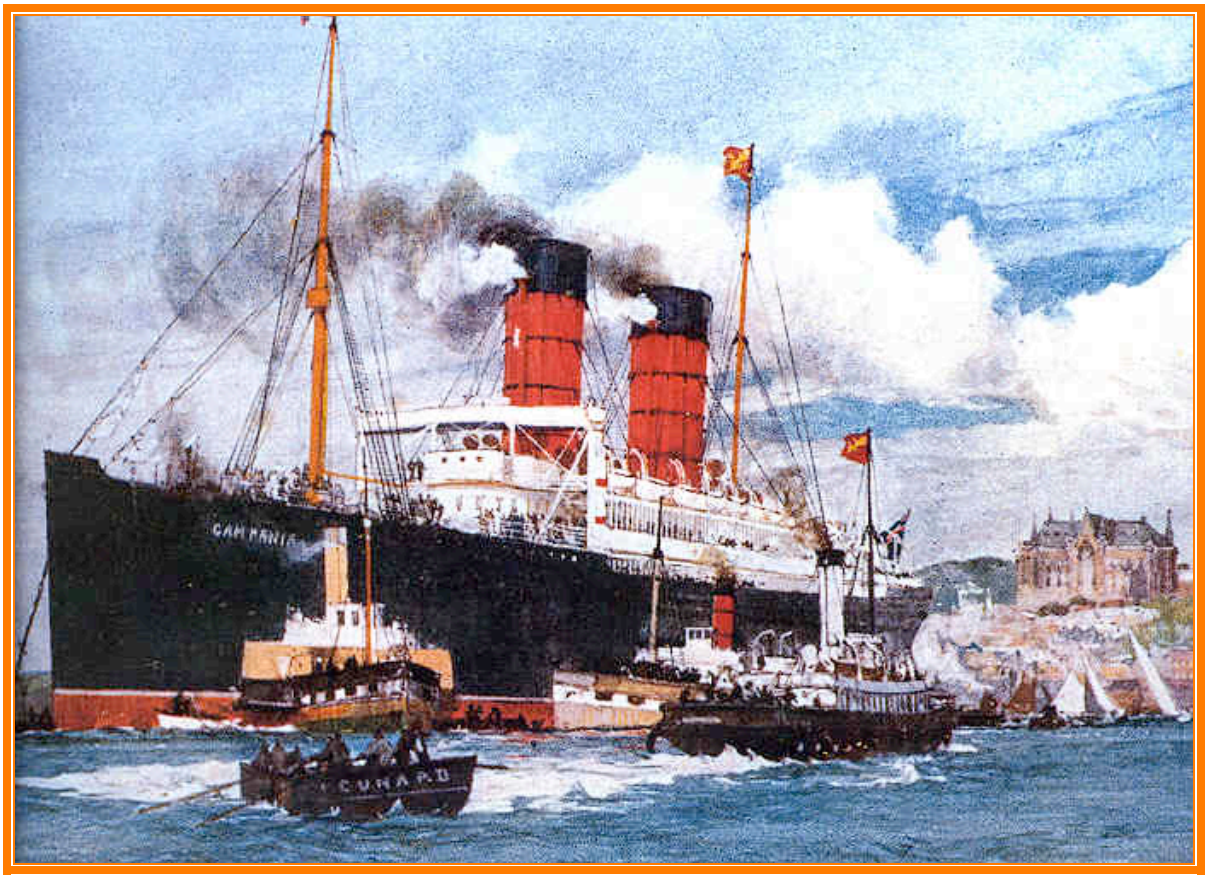
While the records are somewhat confusing, it seems probable that *electric convector heaters* were used on the *S. S. Oceanic* and *St. Paul* (1895). It appears that these applications were experimental and were used to overcome some of the faults of the *American* system. *Thermostatic control* of the electric heaters was tried with varying degrees of success. Even at this early date the economy of thermostatically controlled heating systems was appreciated and was particularly emphasized by the manufacturers of electric heating equipment in order to offset the high cost of producing electricity compared with steam.

Among the several new systems introduced by 1900 was the *reverse system*, one of the earliest applications of which was made on the Cunarder, *Invernia*. This system included a fan, pipe coil air heater with steam traps, and by-pass and other dampers so arranged that hot air was supplied directly to the space when heat was required, and vitiated air could be extracted directly from the space (by manipulating the dampers and using the same fans and ducts) when ventilation was desired. Air supplied to, or exhausted from, adjoining passageways and corridors by natural means completed this system, which was most popular in Europe. As there were no means for automatically controlling the hot air temperature, manual control of by-pass dampers was necessary to achieve the desired result. In 1900 thermostatic controls of the pneumatic type were first used to regulate the

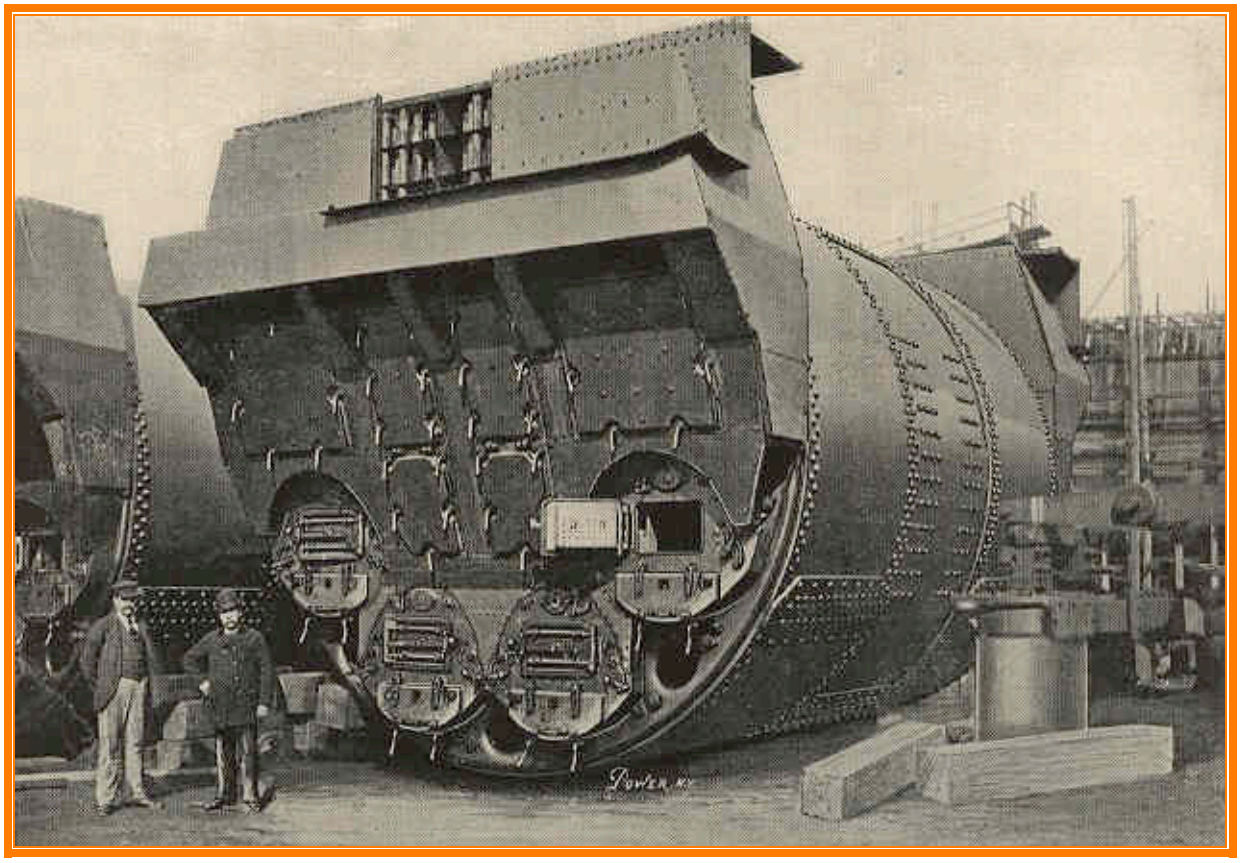
†Presented at a meeting of the New York Chapter.

*Chief Ventilation and Heating Branch, Technical Div., U. S. Maritime Commission. Member of ASHVE.

Battleship USS Indiana 189, 10,288 tons



Campania 1893, 12,950 tons, 598 x 65 feet, Cunard



Boiler of SS St Paul, American Line, 1895 (Mechanical Draft, Sturtevant, 1899)

Battleship USS Virginia 190, 15,000 tons

heating system on three German passenger vessels.

Another system was the *double (dual) duct system* which is still popular. This system consisted of a fan and twin discharge ducts, each of which distributed air to the respective spaces. One duct was fitted with hot blast heating coils. By means of this arrangement, the temperature of the heated space would be varied by adjusting the volume of hot and cold air entering the space. As an improvement of this system a tempering coil was introduced in the cold air duct to prevent cold blasts of air from reaching the heated spaces. While this system was not common on ships in 1900, it had been installed on the *H. D. M. S. Zeehond* and the Japanese battleship *Asahi*.

The double duct system overcame the difficulty of heating and ventilating inboard and outboard staterooms with the same system. Outboard staterooms required much more heat while the inboard staterooms required much more ventilation (natural ventilation being limited by the lack of airport and similar openings).

A third system which obtained good results and which is most common today "blew warm air directly into cabins, etc., and allowed the vitiated air to pass into the passage and find its way out. . . ." Several cruisers in the Dutch Navy (prior to 1900) were ventilated and heated in this manner.

At this time (1900) *duct velocities* between 2000 and 2400 fpm velocity were common though very little specific data on duct losses were available. Shortly before this time a series of tests was run to convince the Russian Navy of the superiority of hot blast heating. The *S. S. Kostroma* was fitted out with hot blast heating and the *T. S. S. Moskva* with a steam pipe coil heating system. The tests showed that the hot blast system produced 26 F rise in 1½ hours while the steam system obtained only a 4 F rise in the same time.

The fact that inside staterooms always have been unpopular is well known. The Bibby Line arrangement introduced shortly before 1901 is an example of the numerous schemes used to obtain *all outside staterooms*. This arrangement provided a narrow passage between the stateroom (inboard) and the ship's side, at which point an airport was fitted.

The introduction of motor driven equipment had an appreciable effect on the design of ventilation systems, particularly on warships. With engine driven fans it was necessary to use a few large units with long distributing ducts, in order to reduce steam piping to the engines. The ducts frequently pierced watertight structures, thus necessitating the use of many watertight closures. When motor driven fans were made available, the practice changed and many smaller fans were used in order to eliminate the long runs of ducts and watertight closures. A notable example of this is the *U.S.S. Olympic*, in which, when it was remodeled about 1902, the two original steam driven fans were replaced by nine electrically driven supply and exhaust fans.

In 1903 *cast-iron radiators* were introduced and effected a reduction in weight as they were far more efficient than the pipe coil radiators common at that time. Radiators were used for heating some of the spaces on the *U.S.S. Battleship Virginia* (1905).

An article published in 1904 indicates that the introduction of submarines presented new ventilation problems. Referring to Dutch submarines, this paper states, "The ventilation arrangements, both on the surface and submerged, are also declared to be bad." Another paper published in the same year reported that mechanical ventilation was provided for the holds of the Anchor Line vessel, *Italia*.

In 1905 Admiral D. W. Taylor presented his classic work, *Experiments with Ventilating Fans and Pipes*, to the *Society of Naval Architects and Marine Engineers*. This paper described the results of approximately 15 years of research and experimentation. Admiral Taylor introduced the present standard method of testing fans, which was radically different from the method used at that time and therefore was violently opposed. The paper also revolutionized the fan industry and emphasized the value of the Pitot tube for air measurement. This study also included a scientific investigation of friction and other duct losses and was probably the first complete work on the subject.

The results of Admiral Taylor's investigation were reflected in the design of the U.S.S. Armored Cruisers, *West Virginia* and *Maryland*, in which various combinations of natural and mechanical ventilation were utilized depending on the particular nature of the space served. In the engine room mechanically supplied air was distributed to the watch stations.

The S.S. *Lusitania* and *Mauretania* (1907) were ventilated and heated by the reverse system, which was used for both passenger and crew accommodations. Electric fans were used and the heaters operated on 30 psi steam pressure. Exhaust ventilation was provided for galleys, pantries, baths, and similar spaces. Because of heating difficulties dual duct systems were provided for the inside staterooms after these ships had been in service a short time.

By 1908 *bracket fans were quite popular*, and *electric punkahs* were used on the *S.S. Omrah*. The latter consisted of a fabric screen supported by a horizontal shaft attached to the ceiling. The shaft was linked to an electric motor in such a way that the screen oscillated to create a movement of air.

Ozone was first used on the *S.S. Makura* in 1908, for purifying the ventilation air supplied to the cabins. In 1913 it was used on the *S.S. Imperator*. This vessel was also notable for the fact that it was the first one which did not use cowl ventilators. The *Kaiser Franz Josef I* (1911) was equipped with both steam and electric heating.

The *Aquitania* and *Transylvania* (1914) had reverse ventilation systems, and heating was accomplished by means of a two pipe steam heating system with radiators operating under 5 psi steam pressure. A special type fan was used to ventilate the engine rooms. This fan was similar to a backward curve centrifugal fan without a casing. Each fan was mounted vertically in the engine room at the lower end of the intake trunk so that the air was diffused by the fan.

In 1923 a steam jet refrigeration machine was invented and patented by the *Société des Condenseurs Délas*. Brine was used as the circulating medium.

While bracket fans and electric punkahs were frequently provided to obtain the cooling effect associated with air motion, it appears that up to 1924 no effort was made to introduce the ventilation air into the space to accomplish the same result. Punkah louvers were introduced first about 1925 on the *T.S.S. Caledonia* and this device is still common today and consists of a ball and socket arrangement which permits directing the supply air (at very high velocity) to any desired location.

An article published in 1926 stressed the importance of humidity in cargo hold spaces. The idea was apparently new as the paper discussed both the development of means for controlling and measuring the humidity. The importance of eliminating carbon dioxide when carrying apples was also emphasized. Since 1926 considerable research has taken place, and operators now realize that ventilation must be controlled to suit the relation between humidity in the outside air and hold. The *S.S. Exporter* (1938) was the first vessel to be fitted with a dehumidifying system for eliminating condensation and allied damage to cargo.

The *Queen of Bermuda* and *Monarch of Bermuda* (1928) were probably the first vessels to use the modern axial flow fan, which has since largely supplanted centrifugal fans in both naval and merchant vessels.

The advent of motor vessels increased the problem of ventilating engine rooms. Reports indicate that very unhealthy conditions existed in these spaces due to the leakage of exhaust gases and the vaporization of lubricating oil. It is interesting to note that the introduction of this type of propulsion also accelerated the scientific investigation of noise prevention and insulation on ships. An article written by G. Robinson in 1931 discussed the theory of sound control and specifically mentions that the *M/V Britannic* had sound insulation on the engine casing and on the deck over the machinery space. This paper also mentions that sound insulation was provided for cabins on the *M/V Ulster Queen.*

The *S.S. Mariposa* (1931) was the first American ship and the second ship in the world equipped with modern air conditioning.

The *Normandie* (1935) was the first ship on which all heating and ventilating equipment was housed inside deck houses or the main structure. This arrangement greatly improved the vessel's appearance because the profile was not distorted by ugly cowls, mushrooms and similar appurtenances. This practice had the additional advantage of providing greater unobstructed deck space, and also of simplifying and protecting the ventilating equipment. The *Normandie* was possibly the first vessel equipped with sound-proofed fan rooms. In addition, it was the first vessel to have central control of fans for fire protection.

The *Queen Mary* (1936) was exceptional in several ways. Diffusers were used for distributing the air in the engine room. In addition to soundproofing of fan rooms, fans and motors were placed on cork anti-vibration mountings. While staterooms were fitted with punkah louvers, ceiling diffusers were used for distributing the air supplied to public spaces. Five air conditioning systems served the cabin class restaurant and lounge, tourist class dining room, and hairdressing rooms. Automatic (pneumatic) temperature, humidity, and damper controls were provided for these systems. A steam jet refrigeration system, said to be the first to be installed on board ship, was used with most of the air conditioning systems. Like many other large passenger ships built at this time, electric convectors with double casings were provided for heating the better class staterooms and suites.

The *Queen Elizabeth* (1938) had considerably more air conditioning than any ship previously built and the steam jet refrigeration system was the largest of its kind.

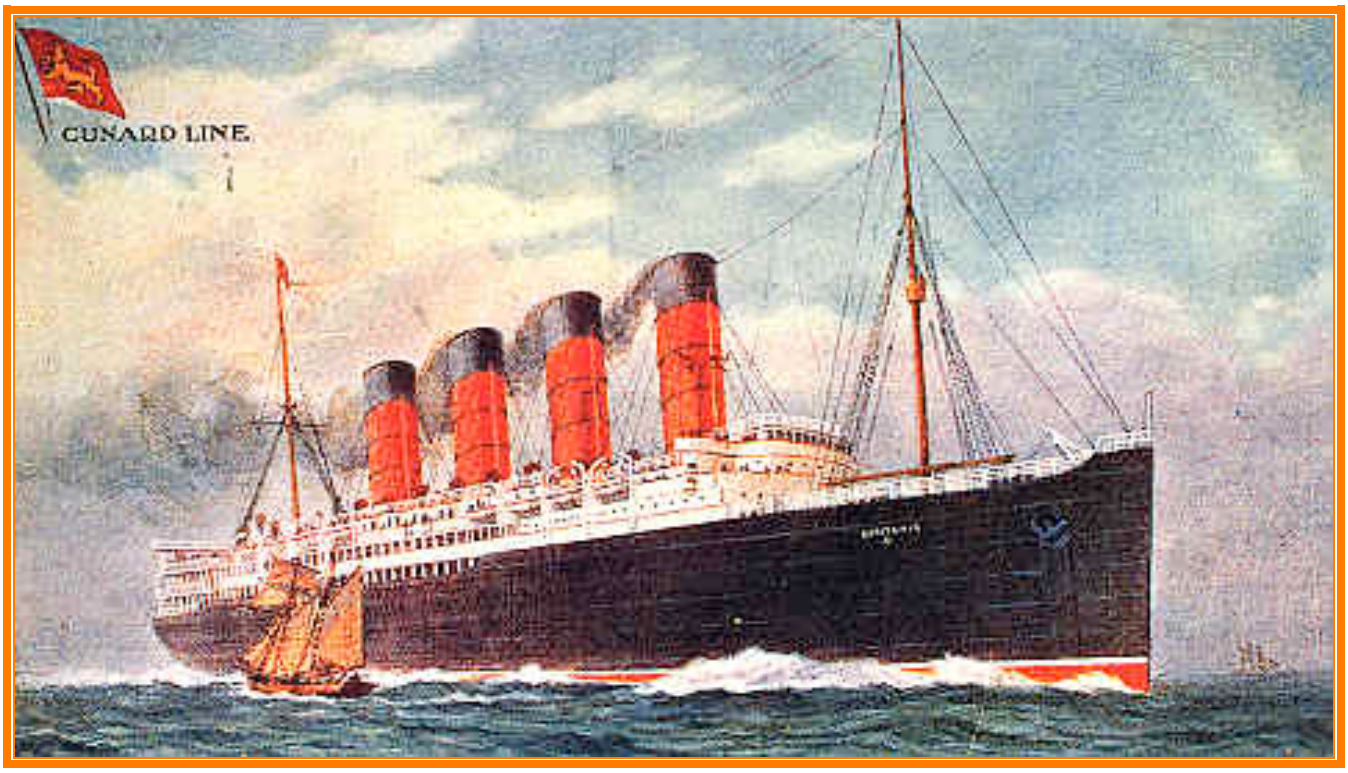
The extent to which air conditioning will be adopted in the future is indicated by the design of numerous vessels, the construction of which was curtailed by the present emergency. Four vessels were designed for the Moore & McCormack S.S. Co. in 1939 which were equipped with air conditioning in all public spaces and staterooms. These vessels were partially completed before they were assigned. Separate air conditioning units were provided for each stateroom consisting of filters, heat transfer coils, blowers, casings, and thermostatic controls. Preheated air was supplied to these units during the heating cycle and "Freon 12" was used as the refrigerant for precooling purpose. Hot or cold water was supplied to the heat transfer coils of the stateroom units.

In 1940 three vessels designed for the Alcoa S. S. Co. were provided with a new method for heating and ventilating the passenger staterooms. Filtered and preheated air was supplied to thermostatically controlled room booster heaters. Heat was supplied to the booster heaters by means of a one-pipe forced hot water system constructed of copper pipe and special flow fittings. Wall registers were used to introduce the air to the treated space. Recirculation of 50 per cent of the air handled was also provided. The above design was advantageous in that summer cooling could easily be added at any time without making major alterations in the original system.

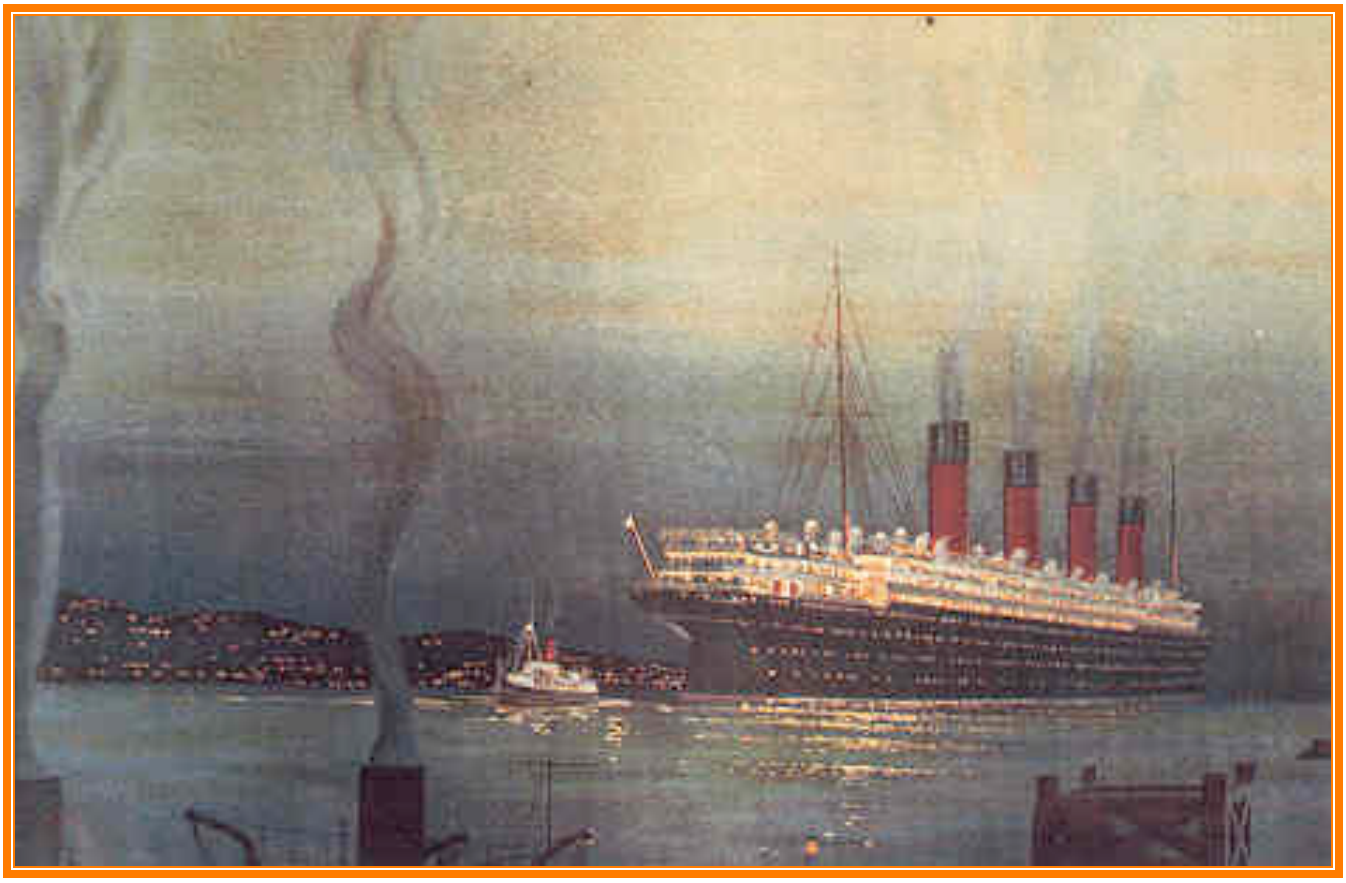
The foregoing history relates the progress made in 50 years of development in the art of ventilating, heating and air conditioning ships. It is evident, however, that the methods of ventilating and heating most common today are basically the same as those used many years ago. The progress, therefore, consists chiefly in the greater application of comfort systems, and the perfection of details and equipment which improve economy of design and operation, as well as closer control of conditions.

Progress continues and while we may not be able to predict the type of system which will be in use after another 50 years, the following predictions may be made:

1. Greater strides will be made in the next 50 years because of the great progress being made in comfort and industrial conditioning research.
2. Ships must compete with other forms of faster transportation, by providing better comfort conditions and delivering cargoes in better condition.
3. The traveling public is *air condition conscious* and demands comfortable accommodations all year round in all climates. No American built vessel will be constructed without extensive *air conditioning* for public passenger spaces and staterooms. Also, many vessels will have *air conditioned* crews' accommodations.



Lusitania 1907, 31,550 tons, 787 x 88 feet, Cunard



Mauretania 1907, 31,398 tons, 790 x 88 feet, Cunard
(Blue Riband holder for 20 years)