RESEARCH IN RELATION TO SHIP FIRES

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SUMMARY

The paper summarizes the history and experience which have formed the basis of the approach to fire protection in passenger ships in this country. It describes the research and testing work that have been carried out over many years in connexion with the fire resistance in buildings, and the adaptation of this work to the construction of passenger ships.

Fire protection in ships depends not only on construction but also on provision for detection and extinction of fires. Recent research in both these fields is described and discussed.

HISTORICAL INTRODUCTION

The British Fire Prevention Committee, established in 1897, and which consisted principally of architects, surveyors and other representatives of non-marine authorities, took part in an International Congress in London in 1903, and established a standard fire test for parts of land buildings. The Committee had a Fire Testing Station in Regents Park, and the results of its work are reported in the well-known series of "Red Books" of which there are some 268. A standard fire temperature of 1,500 deg. F. was laid down by the Committee for test purposes and elements of building construction were graded according to whether they would withstand the standard fire test for ½, 1, 2 and 4 hours.

The Safety of Life at Sea Convention 1914 contained the following articles regarding fire protection in passenger ships: —

Article XII.—In parts of ships above the margin line there shall be fitted fireproof bulkheads which will serve to retard the spread of fire. The mean distance between any two consecutive bulkheads of this description shall not be greater than 40 metres (131 feet). Recesses in these bulkheads shall be fireproof, and the openings in these bulkheads shall be fitted with fireproof doors.

Article XLIX.—

(1) A continuous patrol system should be organized so that any outbreak of fire may be promptly detected.

(2). . . . .(7)—Refers to pumps, fire extinguishing appliances, etc.

The British Fire Prevention Committee criticized the Fire Protection Articles of the 1914 Safety of Life at Sea Convention, and put forward proposals in excess of the Convention requirements. These proposals, which included a demand for statistics of fires at sea, deplored the fact that a sub-committee of fire experts had not been set up, stressed the need for fire prevention and called for a standard fire test, and regulations regarding fire detection, upcasts and fire fighting. One statement made by the Committee was that spacing of 131 feet was too great for fire divisions—fire compartments 66 feet long by 66 feet wide by 20 feet high (2 decks high) were recommended.

After the first World War, the Marine Department of the Board of Trade prepared Instructions to Surveyors regarding the application of the 1914 Safety Convention. In the part dealing with fire protection it was realized that the term "fireproof" bulkhead was a misnomer. It was considered that any material or structure capable of resisting a fire of temperature 1,500 deg. F. for one hour could be regarded for practical purposes as acceptable. It was also obvious that the primary purpose of the so-called fireproof divisions was to retard the spread of fire. The term "fireproof" was, therefore, omitted from the Instructions to Surveyors, and "fire-resisting" was substituted, and this was associated with the standard test of 1,500 deg. F. for one hour which had become accepted practice for certain divisions in land buildings. The work and records of the British Fire Prevention Committee were taken over by the National Fire Brigades Association in 1928. This Association had a testing establishment at Bromley-by-Bow, and tests of materials, fire-resisting divisions, doors, etc., were made in this establishment in the presence of Board of Trade Surveyors before they were accepted for use in passenger ships. In 1935 the Fire Offices' Committee, the central committee of the Fire Insurance Companies concerned with insurance of buildings on land as distinct from ships, opened a Fire Testing Station at Boreham Wood, Hertfordshire, with facilities for full-scale fire-resistance tests. After the second World War the Joint Fire Research Organization was established in partnership between the Department of Scientific and Industrial Research and the Fire Offices' Committee, and the Fire Testing Station was incorporated as part of the permanent establishment.

The 1929 Safety of Life at Sea Convention(1) did not prescribe very much more in the way of fire protection in passenger ships than did the 1914 Convention, but some serious fires in passenger ships in the early 1930s focused renewed attention on this matter. In 1932, the Marine Department of the Board of Trade initiated the reconsideration of the British position and standards. As a result a Committee was formed from the shipping industry to investigate the whole matter. Meanwhile, the Board of Trade also made investigations and prepared draft proposals. It might be emphasized here that the serious fires at sea in passenger ships which occurred at that time were not in British ships.

Authorities concerned with land buildings had found it necessary to lay down various grades of fire resistance of structures, according to circumstances. From the opening of the Fire Offices' Committee Fire Testing Station in 1935 until the establishment of the Joint Fire Research Organization in 1946, research on fire resistance was carried out at Boreham Wood by the staff of the Building Research Station of the Department of Scientific and Industrial Research. Both the Fire Offices' Committee and the Building Research Station were represented on the British Standards Institution Committee which prepared B.S. 476:1932(2), laying down a new

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standard fire test and a grading of fire resistance. This included a restriction on the rise of temperature on the side of a division remote from the fire.

The Marine Department of the Board of Trade drafted proposed Instructions to Surveyors, and these included the division of passenger ships into main compartments by fire-resisting bulkheads of 1-hr. resistance, and sub-compartments by fire-retarding bulkheads of ½-hr. fire resistance as defined in B.S. 476:1932. These proposals were submitted to the shipping industry in 1937.

Meantime, the automatic sprinkler system for the protection of accommodation spaces in passenger ships against fire was coming into prominence, and a number of British passenger ships had already been fitted with such a system, although it was not required by the Board of Trade regulations. In 1939, the shipping industry suggested to the Board of Trade that an automatic sprinkler system should be fitted in all new foreign-going passenger ships, but that if this were done only the main fire-resisting divisions spaced 131 feet apart need be fitted. The outbreak of war in 1939, however, prevented further consideration of the problem.

After the war, working parties were set up to advise the Ministry of Transport (now the Ministry of Transport and Civil Aviation), which had taken over the functions of the Marine Department of the Board of Trade, on the policy to be adopted at the proposed new Safety Convention to be held in 1948. In preparing the United Kingdom proposals regarding fire protection in passenger ships, the advice of the Fire Research Station was obtained.

The United Kingdom Delegation proposed what is now known as Method II of the 1948 Safety Convention[3]. This included the installation of an automatic sprinkler, fire detection and fire alarm system in all accommodation and service spaces, together with fire-resisting bulkheads of "A" Class dividing the ship into main vertical zones 131 feet in length, and "A" Class bulkheads bounding machinery spaces, main stairways, lifts and control stations, but with no restriction on the use of combustible materials in the accommodation and service spaces. This was agreed at the Convention as one of the acceptable methods of fire protection in passenger ships.

The other acceptable methods are Method I and Method III.

Method I requires all the "A" Class bulkheads prescribed in Method II, but does not require the installation of an automatic detector or sprinkler system in the accommodation and service spaces. Instead, it requires all the divisional bulkheads in these spaces to be fire-retarding of "B" Class and in ships carrying more than one hundred passengers, these bulkheads and all linings, grounds and ceilings, are to be made of incombustible materials.

Method III requires all the "A" Class bulkheads prescribed in Method II and the installation of an automatic fire detection system in the accommodation and service spaces. In addition, the latter spaces are to be divided into zones of specified area by "A" Class or "B" Class bulkheads, and the use of combustible materials and furnishings is to be restricted.

In all three methods, special rules are also laid down regarding ventilation systems, air spaces behind linings, and highly flammable paints and varnishes.

The "A" Class bulkheads are to be of steel and so constructed and insulated as to withstand the standard fire test for 1 hour with a limited rise of temperature on the unexposed face. The "B" Class bulkheads are to be constructed so as to withstand the standard fire test for 30 minutes with a limited rise of temperature on the unexposed face.

In the Construction Rules for Passenger Ships made by the Ministry of Transport in 1952[4] [5], all the three methods of fire protection described above are acceptable, but in addition, in Method I, an automatic fire alarm and fire detection system is required in the accommodation and service spaces, and in Method III, in ships carrying more than one hundred passengers, the "B" Class divisions must be constructed of incombustible material.

Since the 1948 Safety Convention, prototypes of all new methods of construction proposed to the Ministry of Transport for acceptance as "A" Class and "B" Class divisions, including doors, shutters, etc., have been tested at the Fire Research Station in the presence of Ministry of Transport Marine Surveyors.

COMPARISON OF SHIP AND BUILDING FIRES

The problems of fire protection in ships are basically similar to those in buildings on land, but whereas a fire in a building can usually be attacked from all sides and at any level, a ship resembles a huge basement and a fire may have to be attacked from above, the worst of all situations for the fire fighter. The conditions of ventilation favour the accumulation of smoke and hot gases in which fire fighting, even with the aid of breathing apparatus, may be beyond human endurance. Moreover, in a ship the proportions and dimensions of the main escape routes are often different from those usually found in buildings. Modern fire protection arrangements take these factors into consideration. They begin with the design and construction of the ship itself, and include a great variety of precautions, from regulations governing the carriage of cargo to the installation of protective devices such as sprinklers. It is necessary in considering the desirability or adequacy of any given precaution to remember that it is part of an intricate system; experience shows that it is not possible to rely completely on a single precaution, although any one precaution may prove of vital importance under some circumstances.

STRUCTURAL FIRE PRECAUTIONS[2, 6-13]

The first principle of structural fire precautions is the visualization of a building as a collection of compartments the boundaries of which are capable of resisting the passage of fire for some specified period. This principle was adopted by the International Convention in 1948[3, 14] in making the first requirement for ships carrying more than twelve passengers the sub-division into main vertical zones by type "A" bulkheads which, where they are effective, form the main barrier to the unrestricted growth of fire. It goes without saying that, to be effective, the boundaries of compartments must be imperforate, but it is impracticable to maintain this ideal under normal working conditions. The main bulkheads are perforated by doors, trunkings, and other services, and it is necessary to go to great lengths to ensure that in the event of an outbreak of fire any openings can be immediately, and effectively closed.

There is scope for reflection in the fact that in recent years in all the major fires that have occurred in ports, the bulkheads were never able to function because of the many open doors.

The Convention requires that doors shall provide the same degree of fire resistance as the bulkhead in which they are situated. To comply strictly with this requirement may entail using an elaborate and expensive door, since the same temperature limitation applies to its unheated side as to the bulkhead in which it would be situated. Since it is unlikely that flammable material would be in contact with a door, some relaxation of this requirement is made by the Ministry of Transport and Civil Aviation in appropriate cases.

Although the fire resistance of the structural elements must be regarded as the first consideration, the possible hazard of combustible materials used in construction or decoration can be of almost equal importance[7, 12, 15-21]. The problem would be simplified if it were possible to avoid the use of combustible materials. It is necessary to examine each constructional material in order to ascertain whether it can be ignited easily by a small source of ignition, and whether its use in any specified amount, or position, could accelerate the development of a fire which started in the contents of a cabin or other room.

Standard tests are available both for assessing the fire resistance of elements of building construction such as bulkheads, partitions, or doors, and the behaviour in fire of combustible materials such as wall linings, deck compositions, or paints. The tests used in this country are described in B.S.

476:1953[2]. Those for fire resistance are essentially similar to their counterparts in other countries and meet the requirements of the International Convention; those concerned with the reaction of materials in fire are in some respects more informative than those so far in use elsewhere.

FIRE-RESISTANCE OF PROTOTYPE "A" CLASS AND "B" CLASS STRUCTURES

To meet the requirements of the Convention a specimen bulkhead must be submitted to a standard test in which it is subjected to precisely defined conditions of heating. The conditions are those which have been found appropriate for fires in buildings, and are defined by a standard time-temperature curve[2] which was derived from the results of many experiments in this country and in the United States, including full-scale fires in old buildings, experimental fires in rooms with various amounts of contents, and by observations of the results of actual fires. The conditions are severe, and it has been suggested from time to time that although they might be reasonable in connexion with buildings on land they are too severe for the fires likely to occur in the restricted space of a ship's cabin. Full-scale trials carried out under the auspices of the United States Coast Guard[22], and those made on behalf of the Aluminium Development Association by Venus and Corlett[23] provide substantial evidence, however, that the requirements are not unfair in representing the state of a fully-developed fire, and that it would be unwise to consider relaxing the standard. In actual fires the rate of development, the maximum intensity, and the duration of a fire will depend on many circumstances, not least important being the amount of ventilation. Despite the fact that ventilation may be comparatively restricted in many parts of a ship it is wise to cater for the fully-developed fire which might occur.

Experience shows that it is not safe to rely on small-scale tests when considering the behaviour of elements of building construction. Quite apart from the transmission of heat through a building material and from its general behaviour in a fire, the most severe effects are often only apparent in the full-size structure. For instance, the suspension of a door and the way in which it fits into its frame may be of overriding importance and far more significant than the materials of which the door is made, so that any weaknesses would be more serious in a door 8 feet high than in a small-scale model. Again, in composite panels, failures are apt to occur at the junctions of components, or through effects of differential expansion which are only apparent in full scale. Accordingly, B.S. 476:1953 requires tests to be carried out on full-scale elements of structure or, where this is impracticable, on representative sections of dimensions of not less than 10 feet.

The testing equipment in use at the Fire Research Station of the Joint Fire Research Organization which is described elsewhere[24], is unique in the Commonwealth. Similar equipment is available in the United States, and provision is being made for comparable apparatus in France, Germany, Holland and Italy; smaller furnaces are available in Scandinavia.

In order to test insulating materials for "A" Class divisions, for example, a steel bulkhead of standardized design is used. The bulkhead, which is 8 feet high by 10 feet wide, is fixed in a heavy, concrete frame which provides restraint at all edges. Two tests are generally called for on each product submitted to represent the conditions of use in service, firstly, with the material applied to both faces of the bulkhead, and secondly, with the material on one face only. A fire may occur on either side of a bulkhead, and tests of the second type are carried out with the steel exposed to the furnace, since this represents the more severe condition of exposure; when the test is carried out in this way the transmission of heat is greater, and the bulkhead undergoes rapid distortion with the risk of greater damage to the insulation fixed to it. Whenever possible bulkheads should be insulated on both faces, so that there is equal protection no matter on which side the fire occurs.

Of the alternatives recognized by the International Convention, British Shipbuilding practice favours Method II as a system of construction within the main vertical zones, that is to say "The fitting of an automatic sprinkler and fire alarm system. . . . .generally with no restriction on the type of internal divisional bulkheading in spaces so protected" Although tests are carried out at the Fire Research Station on both "A" Class and "B" Class divisions, up to the present calls have been mainly for tests in connexion with the former. Insulating materials suitable for "A" Class divisions are generally non-combustible and fall into three classes:—

(a) Rigid boards, which are screwed to grounds of the same material, and fixed to the bulkhead.

(b) Slabs or quilts of fibrous material, generally fixed by pushing them over pins or clips welded to the bulkhead. In addition, an adhesive is sometimes used between the slabs and the outer face of the insulation covered by wire mesh.

(c) Sprayed coatings, applied directly to the surface of the bulkhead and secured by steel clips bent over within the thickness of the coating.

Boards of the first type are usually of an asbestos composition, a typical density being 36lb. per ft.^{3}; boards ½ inch in thickness on each side of the bulkhead satisfy the test requirements if they are spaced from the steel so that air gaps are provided. With this type of board it is difficult to provide adequate insulation on one side only of a bulkhead if the boards are fixed directly to it, since distortion of the bulkhead is liable to fracture and perhaps displace the boards.

Slabs or quilts of the second type usually contain a basis of asbestos, mineral wool, or glass fibre, with an organic or inorganic binder which usually forms only a small proportion of the composition of the product. There is a wide variation in density of these materials, those tested ranging between 4 and 15lb. per ft.^{3}. The thickness required to obtain the prescribed degree of insulation also varies, especially when the material is applied to one face only of the bulkhead. With many products in this group difficulty has been experienced in meeting the test requirements when they are applied to only one face of the bulkhead, because of distortion.

The sprayed coatings of the third type which have been tested are based on asbestos or vermiculite with a binder. The requisite degree of fire protection can be given to a bulkhead by coatings applied either to one side only, or to both sides; the minimum thickness of insulation required has been found to be ½ inch when it is applied to both sides, and 1¼ inches when it is applied to one side only.

BEHAVIOUR OF MATERIALS IN FIRE

Three tests are of interest in connexion with the behaviour in fire of construction materials, fabrics and furnishings, namely, those for non-combustibility, for the surface spread of flame, and for the flammability of materials in sheet form. The first two are described in B.S. 476:1953[2] and the last named in B.S. 476:Part 2:1955[25].

(a) *Non-combustibility Test*

The non-combustibility test is an arbitrary method of dividing materials into two classes according to whether or not they will flame or emit vapours that can be ignited by a pilot flame when heated under specified stringent conditions. In so far as fires on land are concerned, present thought suggests that this test is appropriate when considering materials that are likely to be subjected to heat continuously, or for a long time, but not necessarily at the temperatures reached in fires. Examples are materials used for hearths, or in the construction of chimneys and flues.

(b) *Surface Spread of Flame Test*

While the general restrictions on the use of combustible materials that apply with Methods I and III are not applicable to Method II, the Convention required of all three methods that, "The concealed surfaces of all bulkheads, linings, panellings, stairways, wood grounds, etc., in accommodation spaces shall be such as will, in the opinion of the Administration, restrict the spread of flame to a satisfactory degree". The Ministry of Transport, as "the Administration", consider a material which reaches Class 2 in the Surface Spread of Flame Test to be suitable for these purposes.

In the test, specimens 36 inches by 9 inches, are placed at the side of, and with the long axis at right angles to, a 3-ft. square gas-heated radiation panel. In this position the temperature of the specimen ranges from about 500 deg. C. at the end adjacent to the panel, to about 130 deg. C. at the distant end. Materials are graded according to the rate of spread of flame over the surface, or to the maximum distance to which flame can spread, Class 1 being the highest grade and Class 4 the lowest.

An apparatus employing the same essential principles as those on which the Surface Spread of Flame Test is based is used in France[26]. With Method III there is a need for greater restriction in the use of combustible materials, and the French regulations[11, 12, 26, 27] not only specify the grade to be reached in the test but limit the amounts to be used in the construction of cabins.

(c) *Flammability of Materials in Sheet Form*

Materials in sheet form present the greatest hazard when they are hanging vertically[28]. A test has recently been devised to grade materials according to their behaviour when suspended in this position. The test has not been available long enough for experience to have been gained of its application, but it is important to note its existence; it should be useful in connexion with furnishings.

The significance of the Surface Spread of Flame Test is discussed by Hird and Fischl[29]. It enables an opinion to be formed of the extent to which the rate of development of fire is likely to be influenced by the extent to which such materials are present in a particular room[30]. Table VIII gives examples of materials of the four classes.

Table VIII. Behaviour of Typical Materials in Non-Combustibility and Surface Spread of Flame Tests

Material	Non-combustibility test	Surface spread of flame test
Certain asbestos products (consisting of inorganic materials)	Non-combustible	1
Plasterboard	Combustible (due to paper)	1
Synthetic resin-bonded asbestos board	Combustible	1
Plywood, or fibre insulating boards suitably impregnated with ammonium phosphate, or treated with certain fire-retardant paints* . . .	Combustible	1
Insulating materials of inorganic fibres with resin binder . .	Combustible	1†
Synthetic resin - bonded paper sheets	Combustible	2
Plywood or fibre insulating boards with distemper, flat oil paint, or certain fire-retardant paints*	Combustible	2
Plywood or timber weighing more than 25 lb. per cubic foot	Combustible	3
Fibre insulating board . .	Combustible	4

* The effectiveness of surface treatments depends on correct application of appropriate quantities

†The classification of these materials depends primarily on the proportion of binder present.

TOXICITY OF COMBUSTION PRODUCTS

Concern has been expressed from time to time about the possibility of a serious hazard from the products of pyrolysis or combustion of new synthetic materials. The consideration of this problem must take into account the fact that the products from the ordinary cellulosic materials that are involved in the majority of fires are themselves highly toxic, particularly with fires in enclosed spaces, and they are, moreover, accompanied by an oxygen deficiency that results in an irrespirable atmosphere[31]. It is unlikely therefore that the introduction of materials such as plastic veneers will increase the toxic hazard. This generalization will not apply to materials such as polyvinyl chloride, where the toxicity hazard is obviously increased by the presence of chlorine. An investigation of the products of combustion of chlorinated plastics has been carried out at the Fire Research Station[32]. Traces of carbonyl chloride (phosgene) were observed but these were of small account compared with the quantities of carbon monoxide and particularly of hydrogen chloride. It was concluded that quantities of the order of 3lb. of plastic in a closed room of 1,000ft.^{3} could present a considerable toxic hazard. Hydrogen chloride is a highly pungent, irritant gas, however, and would give strong warning of its presence.

GOOD HOUSEKEEPING

The main benefit to be derived from structural fire precautions is an assurance that the structure of the ship itself will not contribute greatly to or be seriously damaged by a fire, and that the maximum extent of a fire which breaks out in any part of the ship can be restricted within prescribed limits for some reasonable period. Fires are most likely, however, to occur in the contents, or in connexion with the services, as for instance the electrical equipment of the ship, and it is important to adopt various measures to ensure that outbreaks are kept to a minimum. These measures include a variety of rules and regulations which collectively call for what is known as "good housekeeping"[33-7].

While there is no need to dwell on the importance of these regulations, it will be of interest to refer to a series of investigations at the Fire Research Station that have a bearing on the ignition and development of fire in materials of the kind likely to be carried in ships. The work of K. N. Palmer[38] has shown that fibrous and other finely-divided materials can, when the conditions are suitable, be ignited readily by such small sources as cigarette ends; the immediate effect is a slow combustion that can persist for long periods until it is fanned by a stronger draught into open flaming, or until it comes into contact with some material that will flame readily. A cigarette or lighted match, discarded carelessly during the stacking of certain types of cargo, could result in a fire that may not be discovered for several days.

FIRE DETECTORS

An earlier note which was used in the preparation of this paper was submitted to a number of Chief Fire Officers with special experience in fighting ship fires; without exception and without prompting every one commented on the prime importance of immediate detection of fires and, when the ship is in port, of calling the Fire Brigade immediately. In recent years all the major ship fires have been in port, whereas the fires that have occurred at sea have usually been detected and extinguished during their incipient stages. The inference is that at sea there are more people about and the chance of a fire remaining long undetected is slight. An efficient "live watch" is a most valuable means of protection, both at sea and in port. The number of fires discovered by the "live watch" often form such a large proportion of the whole that there appears to the authors to be a tendency to undervalue the importance of other means of detection. It is evident, however, that some fires escape detection by the watch, and any one of these could be disastrous.

The task of the "live watch" is facilitated by manually operated fire alarms, by means of which a general warning can be given, and the fire crew summoned immediately to the spot. Automatic fire detectors can be of much greater value than the manually operated type because they are less dependent on the human factor. They are particularly important in spaces that are not readily accessible or that are not visited frequently. They are of various kinds. A number of heat-sensitive devices are available which operate automatically either when the temperature rises rapidly or when a predetermined temperature is reached; they indicate the location of the outbreak to the bridge and the fire-control point. Simple smoke-detection systems are often used in holds, or baggage or mail rooms. Air from these enclosures is extracted through pipe lines to a cabinet where the presence of smoke is detected either visually or automatically by means of a photo-cell system.

In recent years there have been a number of interesting developments in fire alarms available for use on land, but not all are suitable at sea. The problem of corrosion is much greater in the humid, salty, atmosphere of the ocean, and the effects of vibration are likely to be greater than those normally encountered on land. There is accordingly a need for great care in selecting automatic detector systems for use in ships, and for a high standard of maintenance.

SPRINKLERS

In this country expert opinion strongly favours the use of sprinklers, which not only detect a fire and give the alarm but immediately begin the work of extinction; this confidence is supported by their excellent record in service both on land and at sea[39]. Even when a ship is constructed entirely of incombustible materials, there remains the hazard of the cargo and of the combustible contents of the cabins, and it is in these that fire is most likely to originate.

The chief objections that have been raised against sprinklers are that occasionally they fail to operate, that sometimes they operate inadvertently and cause water damage, and that the temperature differences in different parts of the world are too great for a satisfactory, single, opening temperature. A study of reports in which sprinklers are reputed to have been ineffective shows that in practically all instances at the time of the fire the system was partially disassembled or intentionally inoperative; in other words the failure has been, so far as is known, in the human element rather than in the sprinkler installation. It is considered, moreover, that the requirements of the Ministry's rules are satisfactory in connexion with temperatures of operation; sprinkler heads operating at 155 deg. F. are fitted in cross-channel steamers operating to and from the British Isles, all other ships being fitted with sprinkler heads operating at 175 deg. F. due to the fact that in general they operate in tropical climates or at least in climates which are normally hotter than that met with around our coast. It is common practice to design them to operate at about 155 deg. F. in accommodation space and at about 286 deg. F. in galleys, drying rooms and similar spaces.

The problem of corrosion is much greater at sea than on land. Sprinkler heads employing soldered fusible links are quite unsuitable at sea[40]; silica bulbs are corrosion resistant, and it is usual to give all the exposed metal parts a heavy silver plating. The sprinkler heads for ships' cabins differ from those commonly used on land, in that the deflector plates are designed to spread the water over the surface and walls of the compartment, rather than to release a fairly uniform shower.

Complete statistics on the behaviour of sprinklers at sea would involve information about the number of sprinklered and unsprinklered ships of various kinds at risk, and comparable figures for fires in unsprinklered ships. In another paper included in this symposium[41], Mr. F. J. Welch has given a general picture of outbreaks of fire in ships from the statistics at present available.

Reports on fifty-five incidents in which sprinklers were involved have been obtained from another source. It is not claimed that these are statistically representative because there is no means of knowing what proportion of outbreaks they represent or what happened in the many fires not recorded. Thirteen of the incidents occurred at sea, seventeen in port, and twenty-five in ships under construction. In forty-four incidents the sprinklers provided the first warning of the outbreak, and in thirty of these they put out the fire before any person reached the scene; in most of the other cases they contributed to the work of extinction, but the crew or Fire Brigade were in time to take some part in fire extinction. In two instances the water supply was not connected but the system was operating under air pressure and gave the alarm.

Still further figures were given by a shipping company relating to fires in certain sprinklered ships during a period of nine years. There were altogether forty-three outbreaks. Only eleven involved open flame and of these seven were detected and extinguished by sprinklers; the remaining four were very small fires which, together with the thirty-two fires which did not involve flame, were detected by patrols or other personal means, and were extinguished before the sprinklers came into action. The company felt that this experience emphasized the importance of fire patrols as the first detectors of fire. While this is true, however, it is also apparent that even with an efficient patrol system some fires can still reach the stage at which they can be detected and extinguished by sprinklers before the patrol can arrive. It would seem reasonable to conclude that, for practical purposes, where the possibility of outbreaks of fire remains, the ideal fire protection measure is a system that will as far as possible eliminate the human element and will detect the outbreak, raise the alarm, and begin the work of extinction.

Among those concerned with the insurance of buildings there is a firmly-rooted conviction that sprinklers have pride of place as a means of fire protection, and that where they are installed every part of a building should be sprinklered and not merely those parts which appear at first sight to be the most hazardous. This view may not yet be fully accepted in the shipping world; it is, therefore, worth recalling that in the handful of fires mentioned in this paper, there were two incidents in which fires started in unprotected areas. Such circumstances can place on sprinklers a load that they are not designed to bear; their function is to prevent the development of incipient fires, and they are not intended to cope with fully-developed fires.

EXTINGUISHING AGENTS[42-57]

It has been suggested frequently that research should be devoted to the development of more effective agents for the rapid extinction of fire in ships. When properly applied, however, the agents already available leave little to be desired. No matter how effective a fire-extinguishing agent may be, the major problem is that of applying it in an appropriate manner at the point of the outbreak and with the minimum delay. If to these requirements is added the desirability of eliminating the possibility of failure through some human error, the importance of fixed installations will be apparent.

(a) Water

Both on land and at sea, water is by far the most common fire-extinguishing agent. A great deal of attention has been given in various parts of the world to experiments and tests to ascertain the most effective way of applying water. There is general agreement that wherever circumstances permit, it should be applied as a spray rather than as a jet, but there are wide variations in opinion as to the most effective pressure and size of drop. In some quarters there has been a display of partiality towards high pressures and the implication that fine droplets are more effective than coarse ones; these opinions have not been substantiated by valid experiments, at least so far as published records show.

After intensive studies of sprays on kerosine fires, a comparison was made at the Fire Research Station[58] of the effect of sprays with three different sizes of drops, on six liquids, covering a wide range of volatilities. The results of the experiments are summarized in Table IX.

The results show that in general the finer sprays were more effective with the more volatile liquids, whereas transformer oil and gas oil were extinguished more rapidly by the coarsest sprays. Other experiments[59] with fires in model rooms indicate that for fires involving cellulosic materials such as wood, paper, or cotton textiles, an adequate rate of application of water is of paramount importance. Full-scale experiments, in which the Station had the collaboration of the Birmingham

TABLE IX—EXTINCTION TIME (GEOMETRIC MEAN OF SIX TESTS) OF LIQUID FIRES WITH WATER SPRAYS

(The liquids have been arranged in the order of decreasing volatilities

Mass median drop size, mm.	Extinction time, sec.					
	Alcohol	Benzole	Petrol	Kerosine	Gas oil	Transformer oil
0·27	2·9	9·3	10·9	4·7	5·8	5·8
0·38	147	57	37	12·1	6·8	5·6
0·49	499	*	93	22·7	4·4	3·2

*In three out of six tests, no extinction took place in 240 seconds, the maximum time of application allowed for the benzole fire. It was therefore not possible to obtain a mean time of extinction.

Fire Brigade[58], also showed that operational factors are probably more important than the size of the drops of water. Experiments with sprays are still proceeding, but no evidence has yet been found in the work at the Fire Research Station to suggest that nozzle pressures higher than about 100lb. per in.^{2} are likely to bring substantial increases in efficiency.

(b) Foam[60, 61]

Foam is suitable for dealing with fires in fats and oils, particularly if there is a substantial source of heat present. It is essentially a device for making water light enough to float on oil. Its function is to provide a blanket which will screen the surface of a flammable liquid from the heat of a fire and, by preventing the evaporation of the liquid, restrict the supply of vapour so that the fire goes out. As will be mentioned below, there are agents that act more quickly than foam but the special merit of foam lies in the fact that the blanket remains for a considerable time and while it is there reignition will not occur.

(c) Vaporizing Liquids

Vaporizing liquids such as carbon tetrachloride or chlorobromomethane are efficient for dealing with certain types of fires in flammable liquids such as petrol or oil. The special merit of these agents, which is shared by carbon dioxide, exhaust gases, steam, and dry powder, is that where they can be used safely they offer the most rapid means of extinction. They are only useful, however, when they can complete the work of extinction with no danger of a flashback when the supply of extinguishing agent is exhausted. The agents are compared in recent publications by Kingman and Colman[62], who draw attention to the fact that the products of pyrolysis of carbon tetrachloride and chlorobromomethane are both noxious or toxic.

(d) Carbon Dioxide, Exhaust Gases and Steam [63, 64]

Carbon dioxide, exhaust gases, and steam are particularly valuable with installations that will deliver them, either automatically or by manual control, to holds or other confined and not easily-accessible enclosures. Cost and convenience are the principal factors to be considered in choosing between them. Enclosures in which these agents have been used should be thoroughly ventilated before entry unless breathing apparatus is worn.

(e) Dry Powder

Dry powder, which consists of finely-divided sodium bicarbonate with an agent to promote freedom in flowing, may be used wherever carbon dioxide is appropriate and is usually preferable to carbon dioxide in hand extinguishers. Recently, fixed installations have become available[65] for special risks such as those of engine rooms; no information is available about their behaviour in service, but there is no apparent reason why they should not give efficient protection.

(f) Wetting Agents

Special wetting agents have sometimes been recommended to increase the efficiency of water. Investigations at the Fire Research Station[66] have indicated that, apart from a few special circumstances, the advantages likely to be conferred are much too small to warrant their use, particularly when, so far as can be seen, their use is unlikely to be critical.

FIRES IN MACHINERY SPACES

The recommendations of the International Convention and the requirements of the Ministry of Transport make full provision for surrounding the main machinery spaces, which contain the largest source of ignition in the ship, by "A" Class divisions. Boiler rooms in oil-fired steamships and engine rooms in motor ships are an obvious and large hazard and the Ministry has laid down detailed regulations concerning oil fuel installations in passenger ships. These regulations are designed to prevent the outbreak and spread of fire but "good housekeeping" as regards cleanliness and upkeep is essential if these regulations are to be of any effect. In so far as it is possible to pick out a single principle as of first importance, it is the provision of means for cutting off the supply of fuel immediately when there is danger of uncontrolled delivery to a fire.

There is perhaps one other aspect requiring special mention, namely the hazard of crankcase explosions. This problem has been under investigation during the last ten years, and the chief results have recently been described by Burgoyne and Newitt[67]. Briefly, it has been shown that crankcase explosions arise through the formation of an explosive mixture of lubricating oil and air which may develop if some part of the engine becomes excessively hot. The explosive mixture may result from a mechanically-formed mist or by condensation of vaporized oil. The overheated part may act as an igniting source. The paper mentioned describes researches that have aimed at early detection of the imminence of a dangerous condition, so that the hazard can be anticipated. Other work, sponsored by the British Shipbuilding Research Association, is proceeding, with the aim of providing means of preventing or mitigating the effects of an explosion should ignition occur.

DISCUSSION

Frequent reference is made in the present paper to fires that have occurred in port, but this is mainly because these are more fully documented in the records of the Joint Fire Research Organization which does not receive statistics of fires at sea. Every one of the points made, however, has a direct bearing on the ship at sea, and in any case, statistics regarding fires at sea have been dealt with by Mr. Welch.

Perhaps the most striking lesson to be learned from the major ship fires of recent years[68-70] is that disasters have occurred not because some fire precaution has been overlooked, but because a number of precautions have failed simultaneously. It has already been mentioned that fire protection depends on a large number of interrelated precautions, any one of which may be critical in some circumstances. Because large fires are fortunately few, it is not possible to say whether the total requirements are, or are not, excessive. The intricacy of the system of fire precautions was fully grasped by the Working Party on Fires in Ships in Port[71, 72]. The Working Party was, of course, preoccupied with the problems of existing ships, and with the hazards presented while they are in port. The Report stresses the marked advantages of the "live watch" at sea, and after directing attention to the frequent failure of the human element while the ship is in port makes recommendations to render such failures less likely. The conclusions of the Working Party were both appropriate and timely and have recently again been brought to the attention of the shipping industry in a Notice issued by the Ministry of Transport and Civil Aviation. It is suggested that the long-term aim should be as far as possible to eliminate reliance on the human element, and it may be useful to examine the situation from this viewpoint.

There can be little doubt that the International Convention reached a correct decision in making its first requirement the major compartmenting of the ship by "A" Class fire-resisting bulkheads. There is equally little doubt that there are great practical difficulties in maintaining the integrity of these divisions. The failures in integrity have so far been mainly apparent with ships in port and under repair, but this should be regarded as good fortune. Any failure at sea could be disastrous. In looking for improvements in the future, special attention should be given to this point. The need for control of dampers in ventilators, and for the blocking of holes through which service pipes pass is well covered in the regulations of all countries. The main troubles arise with the doors, through which temporary cables have to pass when the ship is under repair, but it is possible to conceive various ways in which difficulties of this kind can be overcome.

Besides preventing the spread of fire, the division walls prevent access of air to the fire. The importance of controlling ventilation is well-known to all fire fighters, and two suggestions may be worth recording at this point. The first was made by Mr. Martin Chadwick, Fire Master of Glasgow, namely, that use could be made of asbestos curtains to obstruct air flow down corridors. Recent researches at the Safety in Mines Research Establishment[73] suggest an interesting variation of this principle which might have an application in special circumstances where there is a strong current of air flowing towards the fire. A screen which almost fills the cross-section of a corridor increases the velocity of the diminished supply of air, and smoke which would otherwise spread along the ceiling away from the fire is carried back so that the fireman is able to approach the fire more closely.

The second suggestion was made by Mr. Hayward, Chief Fire Officer, Southampton: It is that when a ship is in port the doors of all cabins should be kept closed. It is folly to leave doors open in the hope that smoke will be visible to a watchman passing the end of a corridor. Experiments at the Fire Research Station[74] have demonstrated that with sufficient ventilation a fire may develop from start to flashover in much less time than the interval between the normal scheduled rounds of watchmen, while fire reports show that numerous fires that could have developed have been stifled and extinguished for lack of oxygen behind closed doors[75].

Although Method II does not call for restriction of the amounts of combustible materials used between the main "A" Class bulkheads the Ministry maintains a close interest in the nature and amounts of such materials, particularly if these are highly flammable. There is a trend in all countries towards a reduction in the amounts of combustible constructional materials, and it is a wise trend that should be encouraged even in sprinklered ships, particularly when it can be done without lowering decorative standards or increasing costs. In the building world it is regarded as axiomatic that if the fire load is reduced there is less to burn, and the structure is that much safer. The same principle applies in ships. There seems to be no reason why, in the long run, virtually the only combustibles outside the machinery spaces should not be those brought by the passengers, and the cargo; the function of the structure will then simply be to resist the development of fires which may arise in the contents.

Where there are combustible contents there is need for "good housekeeping", which is, as already mentioned, described in various regulations. "Good housekeeping", however, depends primarily on the human factor, and the aim of those responsible for the design and construction of ships should be to see that wherever possible fire protection is ultimately independent of an element that experience shows to be so frail. It is suggested in this paper that there are good grounds for confidence in sprinkler installations which bring the extinguishing agent immediately and effectively to the fire. Special installations delivering foam, dry powder, carbon dioxide, or exhaust gases may be appropriate for special local risks. Although such sprinklers operate reliably with the minimum of attention, their importance is such that every care should be given to their proper maintenance. In considering the design of an installation, due regard should be paid to the possibility that a fire in the machinery spaces might result in failure of electric power and of the pumps operating the water supply.

Fires in machinery spaces present special risks, the chief arising from the possibility of a major oil fire. Special thought is necessary in design to ensure the segregation of the fuel supplies, and provision should be made for their automatic shutting off in the event of fire. It should be impossible for the oil to spread to accommodation spaces.

One of the greatest problems in fighting ship fires is the disposal of water[76]. The subject of stability has been dealt with by Mr. H. E. Steel[77], and is beyond the scope of this paper. It may be mentioned, however, that the accumulation of large quantities of water on upper decks has led to the capsizing of several ships in dock. Provision is made in some U.S. ships for a small gap at the bottom of appropriate doors so as to permit water to flow to lower decks and to prevent undue accumulation on the upper decks and in this connexion the recent suggestions of Mr. E. T. Hayward[78] are of interest. If it were possible to ensure that any superfluous water would automatically drain to some predetermined position, it would be possible to install remotely operated pumps by means of which the water could be re-used in fire fighting, and the danger of undue accumulation avoided at the same time.

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Discussion

SIR AUSTIN ANDERSON, who opened the discussion, said that he was probably the only person in the room without real technical knowledge; in other words, the only layman.

He had been deeply impressed with the lucidity of the papers and with the extraordinary way in which they covered the subject. Indeed, they said nearly everything that there was to say on fires, so that he felt slightly like the golfer who had just seen his opponent do a hole in one. What did he do next? However, he might make one or two points, though he realized that they were relatively small ones.

What emerged strongly from everything that had been said—and he felt sure it was right—was how much more the human element mattered in dealing with fires than the material element. There had, of course, to be a balance between the two, but what mattered was human vigilance, human intelligence and human speed in action. The emphasis—as he saw it—from both the Merchant Navy and the Royal Navy was much more on the technical reinforcement of human skill than on the materials used in the construction of ships.

He thoroughly agreed with Colonel Bates that the incombustible ship was not likely ever to be a reality, although as much progress must be made in that direction as practicable. At the same time, to believe in an incombustible ship would be just as dangerous as to believe in an unsinkable ship.

As to the measure of what Colonel Bates so aptly described as the "fire shadow", he himself had once or twice come across what might be a dangerous fallacy. He had seen people groping towards the idea of treating the amount of combustible material in a particular section of passenger accommodation as a measure of the fire hazard, fire risk, or fire load—or whatever it might be called. It was difficult, however, to believe that the number of B.t.u. lurking in the background which might be released in the event of a big fire—in fact, an enormous, uncontrollable fire—was really important. Surely, if that were true, one would be in the position of saying that a large log of wood represented exactly the same fire load as the same log of wood if it were cut up into small pieces and shavings. There must be some other factor to be taken into account. Similarly, if he were told as a passenger that a very heavy fire load had been deposited in his cabin, would he expect to find a sack of wet anthracite under the bunk or a tiny eggcup full of petrol sitting on top of the radiator? What mattered was the things that burned quickly—were inflammable—the things that could make a baby fire catch hold and become big, much more than the amount of stuff that was there to burn ultimately.

It was for that reason, and because so many of these readily burnable things like newspapers, clothing, and so on, were taken into cabins by passengers, that he still thought even more firmly than ever that the United Kingdom was right in putting the emphasis on what might be called active defence in the form of sprinklers rather than on boxing in fires with incombustible materials. Clearly, there was a half-way house between the two, but he had no doubt in his own mind where the emphasis should be.

That would be his first point, and the second one was rather different. In the construction of ships things changed and changes in the design of passenger accommodation influenced fire hazards. Colonel Bates had referred to the use of lighter alloy superstructures and no doubt other speakers would have something to say about this, because it was very important.

Reference was made in the papers to the great importance of starving baby fires of oxygen by keeping cabin doors shut and so on. He agreed that this was important, although it was obviously impracticable in the ordinary life of the passenger ship to keep the doors shut the whole time. But there was one development which had not been mentioned, and he would like to know whether this was a realistic point. He referred to the steady growth of air conditioning in passenger accommodation.

In the old days, owners of ships which went through the tropics were always keen on getting as much natural ventilation as possible. They therefore wanted louvres in cabin bulkheads, and realized that the portholes would normally be kept open. They did what they could to supplement the punkah louvre ventilation with natural ventilation. With air conditioning being introduced on a bigger and bigger scale these louvres would be unnecessary and portholes would be kept shut. These openings would not be wanted in the cabins because they would conflict with the control of ventilation. Thus, he believed that as a by-product of the change in design due to air conditioning, there would be a perceptible reduction in the fire risks in passenger accommodation.

MR. J. LENAGHAN said his remarks dealt mainly with the paper presented by Colonel Bates.

This paper rightly emphasised the importance of the well-trained fire organization always available whether the ship be at sea or in port. The shipowners' problem when passenger ships were in port was very similar in principle to that of the shipbuilders' in the course of fitting-out large liners. There were, however, one or two important differences which perhaps made the shipbuilders' problem the more serious one—the ship was "dead" mechanically and so must rely entirely on shore service equipment; there were vast amounts of combustible material lying around, often in untidy heaps while awaiting assembly into position; the numbers of workpeople on board were large, and all in themselves potential fire igniters; many by the nature of their work did actually handle fire jets (the burner and welder); finally there was the extreme difficulty in recruiting suitable intelligent men as fire patrols and watchmen adequately to satisfy shipyard conditions.

Seamen, whether they were naval or merchant men, were subject to discipline and could be trained and controlled much more effectively than workmen in shipyards. Large passenger ships in the course of fitting-out might have on board between 1,500 and 2,500 men of which only about half or less than half were shipyard employees, the remainder being subcontractors' men. The job of making each man fire-conscious in such a miscellany of the interests was no mean task and could only be achieved if the shipyard fire organization were efficient and vigilant. To make it so, called for a better type of man than usually was available for such work; the unemployables always on offer and for the most part best described as "the halt, the lame and the blind" were invariably a greater menace than the known hazards and should not under any circumstances be recruited for fire patrol work. Also, consideration of the provision of a distinguishing garb for the fire patrols tended to lift the morale of these men and assisted them to stand up and to exercise their authority with greater effect over the many too ready to break rules, ignore notices and sometimes wilfully damage or remove equipment on the site specifically placed for fire fighting purposes. Further, and no matter how efficient the works' fire service might be in tackling fires, their job largely was the prevention of fires and the fewer in number these were the more successful was the organization. Also, they must always remain auxiliary to the district fire service with whom at all times they must have the closest liaison.

Colonel Bates's reference to the use of light alloy materials and his example illustrating the resistance of this material to deformation was of interest. It was doubtful if the authority concerned would accept this as a guide to the general behaviour of such material when subject to heat. Nevertheless, there were so many places where light alloy materials, for various reasons, were preferable to steel and even to other materials that it would be most unfortunate and a retrograde step if any regulation were enforced to delay or prohibit the wider use of light alloys, especially in those places where their need was greatest and where in many cases insulation against heat was not strictly a necessity.

Sprinklers undoubtedly were a most effective extinguisher and warning device. Most passenger ships built in the United Kingdom had a substantial part of the sprinkler system installed at the time of launch and from the commencement of the outfitting stages the system was charged and workable. During the outfitting period there was danger of damage to sprinkler heads, and if too many false alarms were not to occur, these must be sensibly placed, and perhaps more widely, than ultimately would be the case in the finished ship.

Modern trends had increased the fire hazard during the outfitting of a ship. The practice of concealing all steelwork, electric cables and piping in passenger cabins and passageways had increased substantially the wood content in the form of framing and plywood linings, while the improved fire subdivision in the form of additional steel bulkheads and steel boundaries around stairways, etc., in compliance with the requirements of the Safety Convention of 1948 had provided more work for burners and welders. When the steel work on these additional bulkheads and boundaries appeared to have been completed, it was astonishing how many holes still required to be burnt and small fittings to be welded to them, and often after the bulkheads had been insulated or clothed in wood linings.

A brief reference, only in the last paper, had been made about the disposal of water in the fighting of ship fires. It was a tragic occurrence successfully to fight a fire and perhaps then lose the ship by overturning. A knowledge of the dangers of large quantities of water trapped in the cabin-compartmented upper decks was necessary by those directing the fire-fighting operations. Also, it seemed incumbent on those responsible for the design of ships to see that reasonable arrangements were made to guard against these dangers. Further, smaller streams of water from smaller diameter hoses might be equally effective in putting out or restricting the spread of fire as large streams from the present larger-diameter hoses and recent experience indicated that this had been appreciated already.

MR. R. S. MACTIER, C.B.E., B.A.(Eng.) (Companion) said he would like to emphasize rather than comment on a number of points which had been brought out by Mr. Welch and Colonel Bates from the point of view of the experience of his own company.

As operators of a fairly large fleet of uninsured dry cargo liners it was their considered opinion that fire constituted the most serious peril to which their ships were exposed. The papers and the discussion were therefore of exceptional value to shipowners such as his company.

Their own statistics did not cover all minor fires, but their experience followed what was presumably the general pattern in cargo liners; namely, that the most numerous cases of fire were in cargo spaces, and here, as would be expected, fires in port exceeded substantially fires at sea. Also, as might be expected in cargo liners, fires in accommodation were not a serious factor. Engine room fires—other than scavenge belt fires—were not numerous, but in their view they were potentially by far the most serious class of fire. Therefore, over a period of some years, they had made a careful study of the layout of engine room fire-fighting equipment and of engine room fire drill, and he would like to comment on this type of fire.

Their planning of the layout of equipment and fire-fighting technique had been based on the following assumptions:

1. That the most frequent causes of serious engine room fires were:
   (a) Blowbacks and leaks from main or auxiliary boiler furnaces;
   (b) Overflows from settling tanks, or bursting lubricating oil or fuel oil pipes, resulting in oils being sprayed on to hot surfaces, such as exhaust manifolds or furnace fronts;
   (c) Crankcase or exhaust manifold explosions.
2. That in motor ships and modern steamers the seat of the fire might well be comparatively high up in the engine room.
3. That oil fires could seldom be fought from above because of the risk of oil fumes rising from the fire "flashing", the very heavy smoke density, and the comparatively high concentration of carbon monoxide in the upper part of an engine room.

On these assumptions the basic fire drill in the event of an outbreak in the engine room was as follows:

Stage 1. Immediately on the outbreak of the fire the engineer of the watch would sound the fire alarm to the bridge, stop the main engines, move the telegraph to "Stop", and attack the seat of the fire with the nearest available equipment, particularly the foam equipment. Two-gallon and thirty-gallon extinguishers and duplicated fire alarms were situated on two levels, namely, control platform level and on a platform some fifteen feet above this, the exact location varying with the different types of ships. The deck officer of the watch sounded the general alarm, ensured that the main engines had in effect been stopped, and if not—as might happen if the control platform was the seat of the fire—stopped the engines by cutting the fuel supply, which could be done from the upper deck. The deck department was also responsible for closing the engine room ventilators and dampers and the watertight doors, and for stopping the engine room forced ventilation fans. Initially, the engine room skylight should be left open, or in the case of totally enclosed engine rooms the extractor fans in the funnel were left running. It was considered that on balance the reduction in smoke density, and hence more effective fire fighting, outweighed the disadvantage of some increase in air reaching the fire. On the alarm sounding, the responsible engineer officer immediately started the emergency generator.

Stage 2. Namely, the start of the outbreak plus three minutes. Again it was assumed that in the case of an oil fire the fire parties must normally gain access to the engine room through the shaft and/or pipe tunnels. Particular care was taken, therefore, that the tunnel escapes were kept unobstructed and compressed-air self-contained smoke helmets were located in the tunnels or on deck in the way of the tunnel escapes. Incidentally, it was felt that the air bellows type of smoke helmet was of doubtful value in an engine room fire. Based on this plan of fire parties working from the tunnels, it was arranged that the submersible pump and a hydrant were located in the tunnel immediately in the way of the engine room watertight door, which enabled a fire party to attack an engine room fire from the tunnel with a source of water independent of the engine room pumps and mains.

As Mr. Welch had brought out in his paper, the watertight doors were comparatively slow to operate, and his company were therefore contemplating the advantages of leaving these doors open in the initial stages and either relying on the doors at the top of the escape or inserting further airtight doors in the tunnels.

Stage 3. If the master were satisfied that the fire parties in the engine room could not deal with the outbreak he would order the engine room to be abandoned and would:

(a) Ensure that engine room watertight doors were closed.
(b) Close the funnel dampers and skylights and stop the extractor fans, all of which could be accomplished from the boat deck.
(c) From the same site on the boat deck operate the settling tank, service tank, gravity tank and lubricating oil tank dumping valves, which would ensure that all oil in the engine room was run down into the double bottom.
(d) Put CO_2 into the engine room.

They were entirely convinced of what had already been said: that in fire prevention and fire fighting, however much fire fighting equipment was put into a ship, success or failure depended basically on the human element—on a well-drilled and fire-conscious team in the engine room.

Their own fire prevention policy was therefore directed towards:

1. Scrupulous cleanliness in the engine room, including well-lighted tank tops and the washing down of tank tops every twenty-four hours.
2. The absolute prohibition of smoking in the engine room.
3. As far as possible the complete elimination of naked flames in the engine room. In this connexion, an important piece of fire prevention equipment was the self-contained boiler ignition unit, which could not be lit unless it was in position on the furnace front. This unit was being introduced throughout the fleet, and it should eliminate entirely the use of naked flames when lighting-up main or auxiliary boilers.
4. All senior engineers should have gone through a fire course ashore before taking charge in a ship. They had not been entirely successful in implementing this policy because of the heavy turnover of engineer officers and although all the chief engineers had been through such a course, a proportion of second officers had not. It was regarded as particularly important that all those who were in charge of fire fighting parties should be able to act with confidence in conditions of heavy smoke, having seen what fire could look like.
5. A weekly engine room fire drill which would ensure that each officer and rating knew his own individual job at whatever time, day or night, the emergency might arise, and also the position and use of all fire fighting equipment. Chief engineers were impressed with the importance of intelligent and imaginative training in fire fighting, including practice in moving about the engine room freely and carrying out all sorts of work while wearing smoke helmets.
6. Reducing the fire risks when ships were in home ports or on coastal voyages in home waters where the engine room was not manned by its normal deep-sea complement. In such conditions, the fire risk was normally regarded as particularly high, since there was not the time to organize fire drill really effectively, and many of the individuals concerned were not fully familiar with the fire fighting layout of the engine room concerned. There was no real solution to this difficulty except to stress continually the importance of a general attitude of fire consciousness. An effort was made to engender a more acute sense of responsibility in those who were in charge by supplying each ship with an engine room "port and short sea fire log". These logs showed the position of all the fire fighting equipment in the engine room, with its deck extensions, diagrammatically. The engineer in charge was required, when he took over, to inspect each item of equipment and record that he had done so in the log book.

In conclusion, he would say that though his company's ideas on fighting engine room fires were based in part on bitter experience, much was pure theory. It was not easy to produce artificially the conditions of an engine room fire at sea and shore experience did not help very much. He would like to emphasize again what Colonel Bates had said about the very great importance of shipowners exchanging information freely on such experiences as they might have, not only of major but also of minor fires.

COMMANDER R. GREY, R.N., said that Colonel Bates had made the most profound and appropriate statement that had been heard during the whole day—that the only good fire was one which did not happen.

After reading the papers, particularly those connected with the Merchant Navy, one was encouraged to know that so much was done in the design and construction of the merchant ship to prevent fire and in the organization and running of the ship to extinguish any fire that did happen in service.

It was particularly gratifying to a naval officer to notice that, bearing in mind the vastly different manpower available, the Merchant Navy's fire organization was so similar to that of the Royal Navy. After all, imitation was the sincerest form of flattery.

The second impression he derived from these papers was one of utter frustration. In spite of these most elaborate and expensive precautions, the whole thing was frequently brought to naught by the scarcely believable carelessness of someone with a cigarette or a welding electrode. It could hardly be that people did not know the danger of their carelessness, nor could they be unaware that death by burning was about the most unpleasant way of dying that there was. Yet they threw away their cigarette ends almost defiantly. They could be seen doing it. It was almost as though they said, "I know how dangerous it is, but look how tough I am!"

This problem had been mentioned in all four papers and no one seemed to have any answer to it. They seemed to accept a shower of cigarette ends rather as the Israelites accepted manna—as something that descended from heaven. Certainly, in the Royal Navy they had not found an answer. The Naval Discipline Act was no more effective in ensuring that people did not throw their cigarette ends about than any other measure. Any executive officer would confirm that. Within days of new linoleum being laid or new furniture installed, it would be pitted with cigarette burns. After reading the papers one could not fail to be convinced that there would be no need for the symposium at all if the regulations concerning smoking and welding were obeyed.

Further rules and regulations were unlikely to be effective. Procedure such as a general search of all persons going on board a ship would be an intolerable interference with the liberty of the subject, and it would probably not be effective. Even in coal mines, he understood, cigarette ends were sometimes found.

He believed more could be done in publicity and certainly in training. A fire equivalent was needed to the "black widow" poster that was so effective at one time in dealing with road accidents.

As far as education and training was concerned, sailors in both the Royal Navy and the Merchant Navy were already trained to varying degrees, and it had already been pointed out that there were far fewer fires at sea than in port. At one time he had thought of suggesting that perhaps the answer was to get the Chancellor of the Exchequer to make the price of a packet of cigarettes ten shillings instead of whatever it was.

But that did not really seem to be the answer because there were very many more fires ashore where cigarettes were much more expensive than afloat where they were remarkably cheap.

It would seem that the people who needed training most were the host of landsmen who invaded the ships whenever they came to harbour—the stevedores, dockyard workmen and so on. How such training could be given he had no idea. The welder could perhaps be trained in fire precautions during his training as a welder, but to train people not to smoke in dangerous places and not to jettison their cigarette ends far and wide seemed to be a problem comparable in difficulty with training them not to kill themselves on the roads. Perhaps they had a blind spot in this connexion.

He remembered not long ago attending a demonstration at a certain nameless fire ground. The fire consisted of a large pit containing quantities of petrol. At one stage in the operation the demonstrator was seen leaning over the pit with a well-drawing pipe not more than six inches from the surface of the petrol. It did not catch fire!

MR. E. T. HAYWARD, O.B.E., after thanking the Institute for the opportunity to be present, said he would like to underline the very important point made by Colonel Bates about co-operation with the shore fire service. Everyone would agree, he thought, that when a ship was under refit and a fire took place it was indeed a combined operation. The ship's master, the dock authorities, the chief fire officer and the ship repairer must work as one team and incidentally—what was probably more important—know one another.

It was even more important that they should know one another before the fire broke out, so that they met on the deck square as colleagues. It was for that reason that fire authorities should be invited to send their officers aboard ships when everything was at rest. This privilege, he was pleased to say, existed at many ports and it was, indeed, of the very greatest importance.

There had been some reluctance in the past to call the fire brigade as soon as a fire was discovered. He was glad to say that much good work had been done in this connexion owing to the co-operation that had taken place. Many companies now called the fire brigade as soon as a fire call was notified to the bridge and before the officer of the watch went to investigate. If the fire brigade found the fire was under control when it arrived, well and good. They went back to their stations pleased that a small fire had been checked.

He had been interested to read in the paper on naval procedure about the use of small diameter hoses. There was a great field for this procedure; and the question of going on board ship with small diameter hoses and control nozzles was already in use, with a view to cutting down to the absolute limit the amount of water that was used. In the design of ships, he would suggest, there was room for the hydraulic hose reel, such as was sometimes used in buildings—a $\frac{3}{4}$-in. unkinkable hose with a $\frac{3}{16}$-in. nozzle—for immediate attack on a small fire. This cut down water damage and the hose could not be kinked when used in small corridors.

The use of small nozzles, however, brought out one important point. If a fire was to be controlled, it must be instantly located and hit very hard indeed. This meant that men wearing breathing apparatus must be tenacious individuals. They must be medically fit and, probably more important, psychologically suitable for wearing breathing apparatus. It was not easy to select and train men for this work, but it was of the utmost importance that they should be thoroughly trained and really know their job if they were to be put into breathing apparatus.

The discussions about engine room fires were very interesting. One small point should be kept in mind here. It was not generally known that once an acetylene cylinder had fired and had been put out and the valve screwed down it could continue to decompose. If urgent measures were not taken to keep it cool, an explosion could take place some time afterwards.

Finally, the fire service authorities attached great value to the expediency of carrying out combined exercises between the ship repairers, the shipowners and the shore fire service. It was advisable to put the whole of the fire procedure into actual operation, so as to see it at work, see the mistakes that occurred, and—probably—reveal lessons that were useful to everyone.

MR. L. G. STEVENS, R.C.N.C., said that reference had been made to the similarity or difference of approach between the naval service and the merchant service in regard to fires. One speaker suggested that the naval service was in a better position to deal with fires because there was more discipline; another speaker had suggested that there was perhaps not so much difference, after all. One of the points that had struck him in listening to the papers was the large area of common ground which existed in the two services. In bringing together merchant service practice and the naval experience in this matter, he felt the symposium would have rendered a very useful service.

Almost all the speakers had referred to the personal element in fire fighting, and he did not want to cover that ground again, but he would like to underline a point emphasized by Colonel Bates. This was that fire fighting was essentially a defence measure. It was clear that the provision of unnecessary equipment would militate against the commercial efficiency of the merchant ship, and it would militate against the military efficiency of the warship. But personal efficiency cost nothing, and too much emphasis, therefore, could not be placed upon the personal factor. On the other hand, apart from personal efficiency, expensive fire fighting equipment which might be provided could go for nothing.

To turn to one or two of the more detailed points, he noticed that Colonel Bates had mentioned some of the difficulties that might exist in applying some of the naval findings in regard to habitability and the passenger accommodation in merchant ships. He had a great deal of sympathy with Colonel Bates here, and he was not sure that with modern trends the naval service had not to face the same sort of pressure. He did not agree that the logical corollary to metal furniture was asbestos underwear. Indeed, if that were pushed to the limit there might be a tendency towards a general relaxation in fire fighting procedures because it was not desirable to insist on 100 per cent standards of fire resistance in all cases. Rather he would take another leaf out of Colonel Bates's book and suggest that it was possible, by taking care, to maintain or considerably improve the artistic effect without necessarily increasing the fire risk.

The opener of the discussion had referred to Colonel Bates's remark about the fire potential of warships being more calculable. He felt that there was a snag here, as that speaker had mentioned already, but whether that was true or not he was not sure where it led. Calculation of the fire potential would certainly cause a bit of a headache when some of the very dangerous things that had to be put into warships nowadays were considered. But even if the fire potential was more calculable the *fire fighting* potential was not more calculable. Indeed, one of the great problems facing a warship designer in deciding just how much equipment to provide and the captain when deciding, in wartime, how to deploy his resources in the event of fire, was that most often the need would occur when the fire main might be damaged, the pressure might be low due to other demands or to electrical damage, and so on.

One difficulty arose from the fact that increasing demand for electric power in warships resulted in more and more cables being taken through bulkheads. This made it difficult to achieve a fully effective fire barrier. Perhaps Mr. Clarke or one of the other authors might be able to say what success had been achieved in maintaining the requisite standard for fire integrity in Class A bulkheads.

Mr. A. R. G. Wray, M.B.E., said that previous speakers had stolen most of his thunder, but he would like to underline one or two points.

The first related to the human element. It had just been said that even the Naval Discipline Act could not provide a solution. As one who served fifteen years in the Royal Navy on the lower deck, he thought the state of affairs was awful if this was so! Older people always thought they were better than the younger generation, but he could quote two ships to prove his point. It tied up with the question of the human element and the cigarette ends and also with co-operation with the local fire authorities. Here he was glad to say he had found less reluctance on the part, particularly, of chief engineers during the past three years to have fire service people about their ships. This was probably the result of a number of disasters.

He had two important shipbuilding and repairing yards in his area, and from the beginning there had been 100 per cent co-operation. The two ships to which he had already referred were sent there to be refitted and converted for special duty. They were described by the shipyard, the Admiralty and the Home Office as of first importance. One was the Royal tour ship, the *Gothic;* the other was the Festival of Britain ship *Campania.* The latter, from the time she came alongside until she left, was a real fire risk. He doubted whether any ship afloat presented such a fire risk, as those who had seen her could well appreciate. The *Gothic,* for political reasons, was also a fire risk.

The shipyard, by an arrangement with himself, laid down a scheme of fire protection, and one of the points was that there should be no smoking, and *there was no smoking.* There were combined exercises. He used to go down to the yard and meet the yard director, who would go on board and tell the patrol that there was a fire in a certain place. The whole machinery then went into operation and the fire service personnel knew nothing about it until they came on board.

On one occasion as they walked through a companionway in one of those two ships, the director saw a man smoking. He (Mr. Wray) believed this man was a skilled employee of the yard. He was sent to the gate and within about an hour he was given his wages and dismissed. As far as he knew, no other man was found smoking on board that ship the whole time she was there. The Navy could do that too.

But perhaps there was one way to cure the cigarette menace without being so arbitrary—to recognize first, as did the aircraft industry, he thought—that men would smoke and unless they were given somewhere to smoke they would go to out-of-the-way places, and that was where the danger lay. They would go where they could not be seen. In a cotton mill, for instance, they would go to the lavatories or cubby holes on the stairs. It was the same in ships. If they were going to be there a long time and could not be controlled to that extent, the only thing to do was to stop smoking entirely, or alternatively to provide places for smoking. It had been found in industry and it would be found in ships that this cut down the dangerous places into which cigarette ends could be thrown. These were two possible solutions.

He would like to say how much he agreed with Colonel Bates. Colonel Bates's fantasy was his own reality. He had probably given the best paper he himself had ever heard on that particular subject. He also agreed entirely with Colonel Bates on the relationship of the fire load. A lot of nonsense had been written about fire load in B.t.u., etc.

Things were put into a completely modern building that would never burn in the worst circumstances, and common sense had to be used. There was one word of warning that should be given, however. Possibly fire load was not so important, but it was always the weakest link in a chain which governed the strength of the chain. In the compartment, having related the fire load to common sense, one should not put a wall electric fire on the bulkhead alongside the curtains by the porthole. He had seen that in a number of ships and there could be a cabin fire for that very reason. It was stupid, and he did not suggest that the ship designer put it there; it might have been added afterwards by someone in the ship's company.

He sympathized with those who had referred to the non-standardization of extinguishers and the almost illegible instructions. One could always see that this firm or that firm or manufacturer supplied the extinguishers but the layman could never see how to operate them. He had met this problem three years ago with his schools at Birkenhead. They employed some 200 to 250 cleaners, kitchen hands, caretakers and so on. In times of full employment this population was a shifting one and instruction had to be given in difficult circumstances. Transfers were therefore made, giving simple instructions in bold, clear type, which even the most ignorant person picking up an extinguisher could not fail to see.

He had been glad to hear Mr. Clarke's remarks about extinguishers. With all deference to the fire engineers in industry, whom he liked and who were much help to him, their job was to sell. They were not always, perhaps, right in what they did sell. Mr. Clarke sounded a warning that there were certain types of extinguishers on the market today which would do a particular job but were highly dangerous in certain circumstances and should not be used except by people who knew how to use them and in places where they could be used safely or with breathing apparatus.

To exemplify that, two years before the war he had attended a fire in a tramcar in London. It would be remembered that in 1937 or 1938 there was a very bad winter with ice on the roads. The London tramcars had underground conductors and these short-circuited through icing. The fire brigade was called and on the upper deck of the tramcar (the fire was below) they found three passengers unconscious because a certain type of extinguisher had been used on that particular fire. That was in the open and it could be imagined what would happen in a confined space with that type of extinguisher. There were two or three others which were even more deadly but he would not go into that for fear of an action for slander.

The point was important because this was first-aid equipment required to treat the fire quickly and put it out if the procedure were carried out properly. If a company were going to spend money on equipment, let the ship's company and the suppliers see that it was efficient.

He could cast his mind back a few years to a cargo passenger ship which came into dock on her maiden voyage to load for the first time. There was a fire on the second night in No. 1 hatch. It was extinguished with a small amount of water spray and he saw half-a-dozen extinguishers lying around. He said to the deck hands that he was glad to see they had been tackling the fire. They replied that these extinguishers were all empty and they had not been able to use them. It was important, therefore, to examine all extinguishers on board and see that they were charged. This might be an isolated case but he did not think that it was. A similar situation was found in shore buildings where the best equipment was supposed to have been installed. It was never maintained and never even looked at. People should make sure that it was all right and that its use was understood.

He wanted to underline what Mr. Hayward had said about breathing apparatus. In his own service a man was never put into oxygen breathing apparatus unless he was physically fit. The fact that he was a fireman did not necessarily mean that he was fit to wear it. He had to pass a special medical examination and go through a three-week course. If for a month he had not used it he did at least one hour's drill with it, and those who wore it knew the potential dangers.

It was a wise step to turn over to compressed air. The untrained man who did not have the same training as in the fire service was safer with compressed air. Again, however, it was not sufficient to say that the Act had been complied with by having one cylinder on the set and perhaps one cylinder spare. Reference had been made to a fire at sea lasting over four hours. He had heard of fires lasting several days. Could it be guaranteed that one cylinder would be all that was wanted? There should be sufficient facilities to recharge immediately, and this was probably where compressed air would be an advantage.

With regard to the smaller hose and hand-controlled branches, these were invaluable to the man who was not skilled in fire fighting. He could use them much more easily. It did not require so much effort; to get down into confined spaces was easier. He would recommend the Royal Navy and the Merchant Navy to look at the latest type of hand-controlled branch. They saved major damage and had an added advantage in a variable nozzle which would, he thought, go down from one inch to $\frac{1}{16}$ inch. Again, they could be connected to small hoses.

COMMANDER A. G. OLIVER, R.N., said that he wanted to stress first of all the training side in the Royal Navy. Every single man went through the mill annually if possible, for a very full course. If he was not capable of standing up to breathing apparatus that was found out afterwards! He was a little concerned about what the last speaker had said, because at this very moment in H.M.S. *Phœnix* there was a course of Merchant Navy Officers who were going through the fire fighting school, and he did not know that he had the doctor in attendance beforehand!

Reference had been made to the discipline in the Navy and the Merchant Navy; there was a difference between the two services. In the Navy, training had to be given for three different sorts of fires; fires during war time had been well covered by a lot of specially designed apparatus; fires in the normal peace-time service were much the same as in the Merchant Navy; fires in ships while in dockyards, as far as he could gather, were identical with those in the Merchant Navy and were caused by the same men—the dockyard "maties" who did not come under naval discipline, unfortunately. If they did, it would be much easier to stop smoking during refitting and there would not be two fires per ship per week, which was a very serious menace.

Incidentally, there was no "No smoking" rule in the engine rooms of H.M. ships, and he had never heard of any fire caused by an engine room watchkeeper smoking on watch. Nor was there any discipline as regards the type of underwear; but he had not heard of any fire caused by sitting on a hot seat!

He would like to have a little crack, if he might, against Mr. Clarke who did not seem to approve of first-aid appliances. Every fire almost without exception started as a small fire, and first-aid appliances could put out a reasonably fierce fire. A spray of water from a two-gallon water extinguisher could put out quite a large fire and so could foam.

The extinguisher to concentrate on was the one that every single officer and man could handle himself and get to know, so that he handled it with considerable ability. In all H.M. ships there were frequent exercises, and the extinguishers were checked to make sure that they were charged.

Foam was used to put out bilge fires in engine rooms and boiler rooms, but bilges were very complicated. Machinery stuck up and got in the way and care must be taken to cover this with foam or the fire would not be put out. The m.v. *Oti,* as Mr. Welch had said in his paper, had had a CO_2 inert gas generator installed. This was the future for engine room fire fighting in enclosed spaces.

He had read in one of the papers that the main trouble about CO_2 was that after use a fresh charge of bottles must be obtained; the chemist and the inventor between them ought to be able to develop a good fire extinguisher system which produced a heavy inert gas in large quantities, the basic materials being (for example) two liquids which could be kept at atmospheric pressure in ordinary containers, and which, when brought together, produced an inert gas in abundant quantities, preferably without generating too much heat.

It must be remembered also that the fire fighter should not be extinguished, nor the man who was going down into the compartment after the fire had been put out; on the principle of the miner's lamp he should be able to be sure that it was safe to do so.

COMMANDER W. WALMSLEY, R.N.(ret.), said that he was the Fire Officer to the Admiralty and the nominal head of the Admiralty Fire Services in the Dockyards. The dockyard fire brigades dealt with most of the fires that happened on ships when they were refitting, and he would confirm that the welding was the biggest menace. It was his contention, however, that the welder should not solely be blamed. There were chargemen, foremen, inspectors and other people in charge of the work on the ships that were refitting. In his opinion they should take further steps as regards fire safety to a higher level than the welder himself.

Mr. Welch had mentioned broken pipes and the leakage of oil on to hot metal surfaces. Had any consideration been given to the automatic fire valve which was now required to conform to British Standards in oil burning apparatus, B.S.799?

The transmission of fire from one compartment to another seemed to have been well catered for, except perhaps for ventilation, whereby the communication of fire, smoke, monoxide or poisonous gases passed from one compartment to another through ventilation trunks. In one case he had in mind, a galley fire, the usual fat fire, there was transmission through the ventilation trunking along with the scum already in the trunking, to an officer's cabin. The fire in the galley was put out, but the fire brigade were called back two minutes afterwards and told the fire was now burning in an officer's cabin, which was many feet away. That point ought to be given consideration.

He could not speak about merchant ships, but it was known that the production of an inert gas had already been studied and that it could be produced continuously by some means on board ship.

MR. A. M. FIRTH confessed that when he accepted the invitation to attend the symposium he had not read the papers, but felt sure there would be at least some matters upon which he did not quite see eye to eye with the authors, but having read the papers he found that he was largely in agreement with all that was contained in them, and therefore wished to make a few observations and elaborate upon one or two points.

In his paper Mr. Welch mentioned the water spray system for extinction of fires in machinery spaces which had recently undergone prototype tests, pointing out some advantages of the system. Perhaps he might mention other advantages; namely, that the water supply was automatically available at all times to the system and also to the spray nozzles for "at will" application, and did not depend upon the ships' personnel starting up pumps before the outbreak could be dealt with. The system was also suitably sectionized and therefore in the first instance it would only be necessary to operate the one or possibly two sections in the area of the outbreak and not the whole of the system in the machinery space.

It had also a use in connexion with "good housekeeping", in that the portion of the system fitted under the floor plates could be operated at frequent intervals and so assisted in maintaining a clean tank top.

The author mentioned the disadvantage of the size of the pump required, but this could be partially offset by its use as one of the statutory pumps, subject to satisfactory positioning and powering.

With reference to electrical gear the water spray system was arranged so as to prevent water spraying on to open switchboards and so far as was possible upon electrical machinery, but he would suggest that it was preferable to have one or two electrical motors temporarily put out of action, as would in all probability happen with the use of ordinary hoses, than to suffer the considerably greater damage that a major outbreak of fire would cause.

Mr. Welch made reference to an attractive variation of the water spray system, and he would ask him to clarify this, for he believed it was meant that this should be an addition to the fire fighting arrangements in existing ships and in no way take the place of a fixed water spray system.

In this paper, and also in that presented by Messrs. Clarke and Hodges, reference was made to the size of drops and water pressures required in connexion with water spray systems and he would suggest that in the practical application of such a system there were many variable factors which must be taken into account but which were often lost sight of when carrying out laboratory tests in small diameter trays.

These factors were: direction and variation of air speed; the type of fuel involved might not be constant; the fuel might be burning whilst static in a tank; the fuel might be flowing over surfaces which might be either hot or cold; the fuel might be burning on lagging as a wick; the fuel might be burning whilst projected in the form of a spray or jet; the angle of impingement of the water drops on the oil surface could not be constant.

It was the opinion of his firm, following considerable research utilizing areas up to 300 sq. ft. that, in view of the updraught caused by a large fire and the possibility of draught from ventilation, that the ideal water spray for use in ships' machinery spaces should be composed of drops of varied diameter to ensure that under the most severe conditions a good proportion of the water reaches the burning liquid, and this had been achieved by using suitably designed sprayers with a water pressure of 40lb. per sq. in. at the sprayer.

From time to time one heard talk of the so-called fireproof ship, which subject had, he thought, been adequately dealt with by Colonel Bates in his paper; also, he was pleased to have his support of an opinion that he expressed during the discussion of a paper read some years ago; namely, that where light alloy was used and suitably sprayed with water, no heat insulation was required to prevent its collapse in fire.

It was most interesting to note that the records of one company showed that in no instance where the fire was of sufficient intensity to cause the sprinklers to operate was it necessary to call on the pump to continue the discharge of salt water from the sprinklers, the original charge of fresh water in the pressure tank being sufficient.

This, together with the other statistics presented by Colonel Bates, showed up most favourably the value of automatic sprinkler equipment.

Messrs. Clarke and Hodges mentioned certain objections that had been raised against automatic sprinklers, the first being their failure to operate, and he would say straight away that he knew of no such case; surely, if for some reason due to the failure of the human element the engine room staff omitted to start up the ship's engines on receipt of the requisite signal from the bridge, and the ship remained alongside the quay, that would not be classed as an engine failure.

He did know of one case where, due to failure of the human element, the sprinkler equipment was unable to take part in the actual extinguishing of that particular fire; the pressure tank and automatic pump had both been shut off at the same time for examination, and although the ship was in port the sprinkler equipment had not been connected to the shore fire mains, and was thus without any water supply whatever. Nevertheless, despite this failure of the human element, the sprinkler system, due to the release of the bottled-up pressure through the sprinkler heads that operated, gave the alarm, thus enabling the ship personnel to deal with the outbreak at a much earlier stage than would otherwise have been the case. However, he submitted that this was not a failure of the sprinkler system, but a failure of the human element.

It might be that the instances quoted by the authors of fires breaking out in spaces not normally protected by sprinklers and spreading to the protected portions of the ship, causing sprinklers to operate but putting upon them a load they were never designed to bear, had been considered sprinkler failures, but this he did not accept, for, as pointed out by the authors, the function of the sprinkler system was to detect and extinguish the fire whilst still small and not to deal with a conflagration spreading from outside the protected area.

The other two objections mentioned could, he thought, be discounted, for as the authors pointed out, so far as the bulb sprinkler head was concerned the operating element of this head, unlike those employing soldered fusible links which could be seriously affected by corrosion due to salt atmosphere, was entirely immune to corrosion and only heat or mechanical damage would cause a bulb sprinkler to operate.

The question of difference in temperature was of little moment for, under the same conditions of heating, the difference in time of operation would only be a matter of a few seconds.

The authors gave some statistics relating to reported fires and if those of the nature mentioned above, which were not sprinkler fires in the accepted sense, were omitted they were left with fifty-two fires in which a total of sixty-three sprinklers only operated; one sprinkler on forty-three occasions; two sprinklers on seven occasions; three sprinklers on one occasion; and four sprinklers on one occasion—a record which spoke for itself and about which he need say no more.

Returning once again to "good housekeeping", of which patrols were an essential part, he would remind them that a patrol could only visit a specified point of the ship at intervals, and although everything might apparently be in order at the time of his first visit, a serious fire could be burning by the time the patrol again reached that same position. It was therefore of the utmost importance, especially in port, that water supplies to the sprinkler equipment and indeed to the fire-fighting services in general, be kept at the highest pitch of efficiency and although they had of necessity to be shut down from time to time for examination, they should not all be shut off at the same time, and when one was shut off alternative arrangements should be put into force immediately.

MR. R. K. BARLOW congratulated the authors on a marvellous effort which, he said, represented a step in the right direction. He hoped the matter would not be allowed to rest but there was a tendency after a little publicity to forget all about fire security in ships until another bad fire caused it to raise its head again.

He did not wish to be misunderstood. Considerable progress had been made with regard to the security of ships in port. And because little time was available he would confine himself to ships in port. For progress it was essential to get down to basic questions, and there were certain fundamentals —small points, perhaps, but they helped.

He agreed with previous speakers that except with the larger companies patrol systems were hopeless because the men employed were normally unsuitable for the job. He might be putting himself in a peculiar position by saying this, but in many cases the patrols had caused fires themselves. He did not mean by this that there had been arson but it was far better to have no patrol than a patrol which could not be trusted to carry out its functions to the letter. Some of the big companies could afford to and did provide suitable patrolling systems while their ships were in port, and so far so good.

Every type of extinguisher was used on British ships operating from this country but the average man was not concerned with fire. By and large it could be said that often the man with the correct extinguisher available was the only man in the ship who did not know how to use it. This had been discovered over and over again in port, and because he did not understand (a) how to use the extinguisher, and (b) how to call the fire brigade, the fire got out of hand before the fire service got there.

He viewed with horror the idea of using methyl bromide extinguishers. He would risk prosecution by saying that they should be condemned by law. Methyl bromide was, after all, an inert gas, and there were other inert gases with the same or better inhibitory factors which did not have the same lethal effects.

Many shipping companies had brought the regulations for calling the fire brigade in port down to a fine art. They did not necessarily have the lowest fire incidence, but the fires occurring were small ones due to immediate and correct action. If one could be sure of ship to shore lines in every case, not only in certain cases, it would be a big step forward. His colleagues would bear him out that, as had been proven within the past few years, after fifteen to eighteen minutes there was not a chance of confining the average fire to small proportions. If someone was run over by a steam roller, one did not call a doctor but an undertaker and the insurance man. It was the same with the fire service. What was the use of calling the brigade when the fire was burning fiercely and saying that the fire was down below and they hoped the firemen would find it? This could probably take another ten minutes. One could not put water on to smoke, or it was bad fire-fighting practice if one did.

In port, therefore, anything that could be done to ensure that the local brigade was called promptly was well worth doing.

Unfortunately, he was accused a year ago of advising fire prevention by coercion. That was not true at all, and all he asked was that certain sanctions should be imposed. He believed honestly and sincerely that if the main companies were prepared amongst themselves to adopt certain sanctions in collaboration with local fire authorities they would not incur but would save expense over the years.

On Merseyside, particularly during the past three years, shipping interests, dock authorities and fire authorities had been getting very close together and there were a good many ideas proffered about standards and standardization, which was a good step. The service routes of British shipping might be ubiquitous, but let these efforts at fire protection start at home and they would achieve something.

He could not say more in the short time available, but he hoped that the papers would not now be filed away but that further progressive action would be taken in the near future.

Mr. H. E. Bedford (Associate Member) said Mr. Welch had produced a paper stamped with the solidarity that had become a commonplace to expect from him and his associates. The hard-headed facts were set out and rendered more forceful, and yet more readable, by quizzical references to the crux of many fires; namely, "the nobody to blame excuse"; "the humble cigarette"; and the lack of standardized extinguishers. This type of reference served to emphasize these simple causes of serious fires.

The paper had not left much for anyone to seize upon, but he would grasp at the first straw—the isotope level indicator for CO_2. There was no liquid level above, say, a critical temperature of 80 deg. F., therefore, it would only be possible to use it at reasonably low temperatures. Whilst an excellent device under these limited conditions, it could not be effective in *hot* climates.

On manning and training, it was well known that many fire services in this country recruited personnel from ex-seamen. Could not this procedure be adopted in reverse, with considerable benefit to the Merchant Navy? Perhaps he ought not to say that, in view of the strength of fire service personnel present at the meeting.

He would skip any detail of inert gas, because other people were perhaps better qualified to deal with that subject but, in passing, he might mention that something which gave an unlimited supply and yet operated so effectively in the first hour or two on cargo, ensured that the ship could be kept at sea; and a ship at sea was earning money which it did not earn if it had to set course for port, and stay there.

The author had very clearly set out the *pros* and *cons* of the various installations for major fires in machinery spaces, and the final choice was therefore made more difficult. The references to the fallibility of closing openings and shutting down ventilation would seem to rule out methods which were dependent on this for complete success. That left only foam or water spray.

It was useful to remember that foam was in effect light water or water ærated to create a blanket medium which would remain where water would run away. Therefore, what water would do, foam would do better. That was not always so in reverse. After all, it was the water content of foam which was the beginning of its effectiveness. It had to cool something first before it could build up and create its final effect.

Foam could at least substantially control a serious fire without waiting for a fire main to be pressurized and could continue its work after the fire main had been pressurized. This gave it flexibility, which should not be ignored. There were doubtless other ways in which foam could be brought to the rescue, and it had already been mentioned that many fires, particularly on motor ships, occurred above floor-plate level. Obviously it was not possible to anticipate every location where such a fire might occur; but many locations must be obvious when the ship was being built, and it would not seem to be impossible to cover at least a large number of the more important points with foam from the installation normally set up to give cover to the tank tops.

Finally, he would suggest as regards recommendations for future improvements that, from his own point of view, the two most important points were the extension of fire mindedness and the training of personnel in fire fighting. Next in importance would be the maintenance of pressure on the fire main at all times. The others followed in sequence.

Mr. J. A. Smith, D.S.C., B.Sc. (Member) said that the papers had been most instructive and particularly interesting to him where they dealt with hold fires and the equipment for dealing with them.

He suggested that in addition to Colonel Bates's recommendations, it might be valuable to have an up-to-date stowage plan made up nightly and kept on board so that it was instantly available at any time in the night.

He did not consider that sufficient stress had been laid during the discussion on the limitations of the present systems for dealing with hold fires. The experience of his own company of fires in ships' cargo holds had shown that without exception the present statutory requirements for equipment were insufficient for extinguishing fires in the larger spaces. In the smaller spaces CO_2 had been effective, but because the quantity that could be carried on a ship was limited by considerations of space and weight there was no certainty that a fire could be put out.

The gas might be used inefficiently because the hold was not properly sealed, or it might be wasted through indecision or mistakes on the part of the ship's company. There was always bound to be some doubt with a "one shot" system as to when it should be used; and if further outbreaks occurred, the lack of a reserve of gas rendered the ship's company helpless.

Steam had been used for many years, but there was some suspicion that it was really useless for extinguishing fires. Experiments on full-scale hold fires in a Liberty ship were carried out in the United States in May to October 1946 and these went by the code name *Phobos*. Burke in 1949 discussed them fairly fully in his paper*, "Fighting Fire at Sea".

There had been a tendency to discount the results of these trials because only cotton cargo was used, which could not be truly representative of every kind of cargo, but reference to

* Burke, H. J. 1949. "Fighting Fire at Sea". Trans.S.N.A.M.E. Vol. 57, p. 5.

Mr. Welch's Table IV would show that cotton was typical of a very large proportion. The trials demonstrated the effectiveness of even the smallest inert gas generator, and illustrated the defects of steam, which were: it could not cool down the seat of the fire, it gave high boundary temperatures, in some cases over 200 deg. F., and it created a strong vacuum, up to 20 inches of water, when the steam was shut off.

With all the foregoing in mind the plant designed and installed in m.v. *Oti* was made capable of giving an almost inexhaustible supply of completely inert gas which would not only extinguish the flame quickly but would reduce the oxygen in the hold to the point where not even smouldering could continue. It was easy to manipulate and, indeed, during the first voyage all the ship's officers, apprentices, and petty officers down to the carpenter and the bo'sun had learnt to operate it, and the ship's company had gained great confidence thereby.

Practical tests were carried out on the plant, and they were in very close agreement with theoretical predictions.

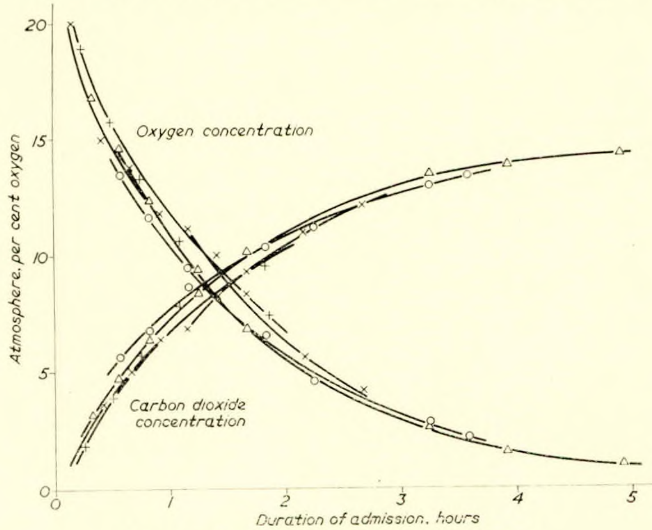

FIG. 1—*M.V.* Oti: *test on 'tweendeck*
Volume of 'tweendeck, 42,680 cu. ft.
Capacity of plant, 35,000 cu. ft. per hr.

Fig. 1 showed the results of Orsat gas analysis during a series of tests and illustrated the effectiveness of the plant by the relatively short time taken to reduce the oxygen to the point where smouldering ceased, in cotton for instance at 8 per cent. Flames would be extinguished at 15 to 16 per cent.

Fig. 2 compared carbon dioxide and inert gas on the scale of statutory requirements, and on the same theoretical basis, which was that a volume of gas entering the hold diffused completely and evenly with the atmosphere of the hold, and swept out an equal volume of diluted atmosphere.

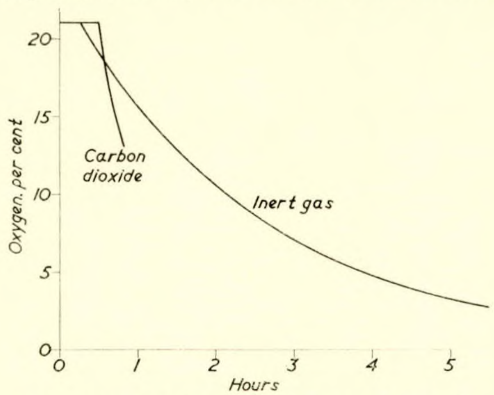

FIG. 2—*Efficiency of systems compared*
Volume of hold, 100,000 cu. ft.
Permeability, 63 per cent
Volume of CO_2*, 30,000 cu. ft. total*
Volume of inert gas, 25,000 cu. ft. per hr.

Although the carbon dioxide could be discharged into the hold rapidly, some time would be required to ensure that the space was closed down so that gas could not escape. The injection of inert gas could begin earlier although at a slower rate. The important point about this was not the extinction of flame, which both systems would achieve in approximately the same time, but the fact that the amount of carbon dioxide was not sufficient to reduce the oxygen throughout the hold to a concentration low enough to prevent smouldering.

The success of the tests on the installation had led to further plants being constructed, and had stimulated thought on the use of gas from other sources and in other ways.

Mr. Welch had made the point that, initially, inert gas was too slow for an oil fire. However, it could be stored under pressure for ready use and reinforced by a further supply of gas from a generator. Such a system was being considered. A very important aspect was the employment of mobile generators. The whole machine could conveniently be fitted on a chassis and used anywhere that there was a supply of cooling water. It could be taken to a ship in port in the same way as a fire engine and the gas could be passed down through a stiff fire-resisting fabric hose, the hatches being covered sufficiently to retain the bulk of the gas, while allowing air to be swept out.

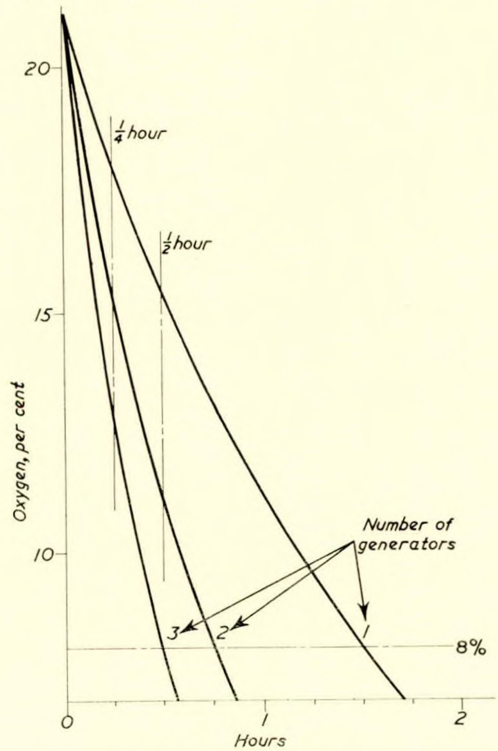

FIG. 3—*Time required to inhibit combustion*
Volume of space, 100,000 cu. ft.
Permeability, 63 per cent
Generator size, 40,000 C.F.H.

Fig. 3 showed how effective such a system could be. A continuous stream of cool inert gas was sweeping through the hold, taking away the products of combustion that might be there, and helping to carry away the heat.

MR. A. J. GREENSLADE, M.B.E., said that he also was a fire officer.

With regard to the paper submitted by Mr. Welch he would make the following observations. The causes of fire were carefully studied by the Research Division at the Home Office in an objective manner so as to secure the fullest possible information, the idea being to prevent similar occurrences. It was admitted that the headings "Spontaneous Combustion", "Smoking" and "Unknown" gave rise to comment in that they provided a convenient method of writing off the causes of fire but he would ask Mr. Welch if he agreed that the sum total of fires would be the same? The specific cause would merely be deleted on the one hand and added to the "Unknown Cause" column.

With regard to electrical causation of fire, he would ask Mr. Welch if he did not consider that more publicity and propaganda should be given as some shocking examples were seen of bad housekeeping on ships undergoing refit in port, with cables trailing over decks and quickly constructed fuse boxes.

With reference to Mr. Welch's comment on the dangers of water in ships when being used for the extinction of fire, he would like to pose the question: was Mr. Welch satisfied that every possible avenue was being explored in endeavouring to find a satisfactory solution to the problem of channelling water from the upper spaces in passenger vessels to the lower reaches of the vessel, so that stability could more easily be made effective?

With reference to Colonel Bates's paper, he would like to pose one or two queries as they occurred to him, having had some considerable experience on Merseyside at a hundred or more ship fires, and his first observation was on Mr. Bates's point regarding the controversial issue concerning the use of wood in accommodation, and here he was more concerned with the passenger vessel. Having due regard to the fact that the Royal Navy was now excluding all combustible material, he was rather at a loss to understand Colonel Bates's reference to the necessity of a totalitarian world to make this possible insofar as passenger vessels were concerned. As "beauty is only skin deep", was it not possible that a quite attractive external surface could be produced with incombustible materials without presenting the rather cold and austere appearance which Colonel Bates seemed to indicate?

Allowing for the fact that incombustible materials were being used at the fire bulkheads, he felt that the distance of approximately 131 feet by some 75 feet on several decks could be sufficient to give any fire officer a headache when concerned with a major fire, bearing in mind the additional hazard of the use of water as an extinguishing medium.

Referring to Colonel Bates's comment that "the ship herself from drawing board to breakers' yard, is wholly designed, built, maintained and operated to offer the greatest resistance, consistent with her functions, to the hazards of the oceans, including fire at sea" appeared to him to be at cross purposes with the paragraph mentioning a totalitarian world, etc. His experience in directing operations on Merseyside for thirteen years, which included such incidents as the fires in the *Milwaukee* and the *Empress of Canada*, permitted him to suggest that the greatest resistance in such ships was not ensured, by reason of the combustible material involved: therefore, would Colonel Bates agree that at the present time every advantage should be taken of scientific research so that the use of incombustible materials should be progressively adopted in seagoing vessels?

Naturally, there might be certain features in vessels of all types which suggested that water sprays should be part of the fire prevention system, but he did feel that an extension of the use of incombustibles might prove that water sprays extensively used in conjunction with incombustible construction might be somewhat of a luxury. He would respectfully submit that he was now putting the case for reducing water for fire fighting to the very minimum.

Referring to the conclusion of Colonel Bates's paper, whilst it was agreed that the physical nature of combustion and the fallibility of man was unalterable, that in itself could not just be written down as an excuse for not going to the utmost limits to offset the particular weaknesses. The Royal Navy had decided to eliminate as far as practicable all combustible material from capital ships. That surely was the logical method to offset the dangers of combustion. The fallibility of man would be well taken care of by this act and the relaxed tendencies of the human element would be relatively and conversely frustrated.

Would Colonel Bates agree that progress on the lines he had suggested might be reflected to the extent that underwriters might interest themselves in the possibility of fire grading of seagoing vessels according to their susceptibility to fire risk?

CAPTAIN W. O. SHELFORD, R.N.(ret.) said that he wanted to talk about breathing apparatus and to be fair he should explain that since his retirement from the Royal Navy he had been employed by a leading firm of breathing apparatus manufacturers. He proposed, however, to speak from his experience in the Royal Navy and as one-time captain of the *Phœnix*.

He disagreed with Mr. Welch's statement that the use of breathing apparatus was controversial. Almost every speaker had mentioned the smoke hazard of fire fighting. Smoke and fumes were the inevitable and undesirable accompaniment of almost every fire in a ship, simply because they could not get away.

Mr. Clarke had mentioned the difficulty of fire fighting in an alley-way filled with smoke with a lot of corners. With so much smoke about, the fire fighter was almost inevitably driven away from the fire and had to attack it from a distance, which many fire officers would agree was an inefficient way of fighting a fire.

A man in a breathing apparatus could get to the source of the fire, which in its initial stages was nearly always fairly small, and if he could get up to it he could tackle it. Therefore he himself maintained that the breathing apparatus must be considered an axiomatic part of the initial attack in any fire fighting effort.

In the past there had been a tendency to think of breathing apparatus as some sort of black art which could not be comprehended by the ordinary mortal. With due respect to Mr. Hayward and Mr. Wray, he thought some of this was due to professional jealousy on the part of the full-time fire officers. Some was due to adherence to old-fashioned types of breathing apparatus, such as the Salvus which was Royal Navy usage. Such types required a certain amount of training and understanding. It should, however, be remembered that men, women and children were using breathing apparatus, usually the compressed air type, for underwater swimming on their summer holidays, and there had been remarkably few casualties all over the world. It was time to stop thinking of breathing apparatus as something which could only be used by the professional. It was high time to begin to think on the line that any seaman or other person employed in a shipyard should be able to put on breathing apparatus when tackling a fire.

There had been references to the smoke helmet, and this was regarded as a nice reliable piece of equipment. It was, in fact, one of the most dangerous pieces of apparatus for fire fighting yet invented, simply because it could not be tested before the toxic atmosphere was entered. It was also inclined to leak. He understood it was maintained that the other forms of breathing apparatus were beyond the comprehension of the ordinary merchant seaman. But he thought many of those present would agree with him that those days should be over.

MR. N. C. STROTHER-SMITH, M.A., said that the most interesting part of Mr. Welch's paper to him was that dealing with the extinction of fires. One aspect might perhaps be studied more fully: the effect on a fire of battening down the holds. The *Phobos* tests seemed to indicate that this had an appreciable effect on the oxygen content at a rapid rate, though the figures could only be used as a rough guide.

By sealing, the oxygen content could be reduced to 6 or 7 per cent at an average rate of 3·2 per cent per hour, and by comparison, with (standard) CO_2 the oxygen content could be reduced to about 5 per cent at a rate just short of 2 per cent per ton of CO_2 in the small cargo tests, and 3½ to 4 per cent per ton of CO_2 in the large cargo tests. These were actual figures obtained from the *Phobos* tests and not figures he had concocted. As a suggestion, he might point out that re-ignition could occur on ventilation.

There was little evidence of the relative successes of the various types of extinguishing systems. Although CO_2 was known to have been used effectively, the exact conditions obtaining in the fire were not known. It would appear, however, from Mr. Welch's Table II that the methods used in British ships had been remarkably successful in relation to cargoes.

It would be interesting to know to what extent success could be attributed to the effectiveness of the system or to the training of the crew. He did not think this information could be obtained from the particulars that were available.

Training had been mentioned throughout the symposium, and there was some evidence in the papers that where it was of a high standard the incidence of fire was lower and the effectiveness of the measures taken very much greater.

It had been said that inert gases were too slow to deal with oil fires. That might be substantiated. With very dangerous cargoes inert gas might be used if fire was suspected or even before fire was suspected.

In his concluding recommendations, Mr. Welch referred to the insulation of hot surfaces to prevent ignition by accidental oil leakage. He himself would like to add to this that the insulation should be of a non-absorbent nature.

So much had been said about vigilance and training that in view of the time any remarks he might have to make could be rushed over. But it was interesting to compare the difference in outlook between Colonel Bates and Mr. Carter and Captain Hogger. In one case fire prevention was almost as valuable as the armour of the ship, hence the almost complete elimination of anything that would burn. The fire prevention in a merchant vessel, however, in the words of Colonel Bates, must be consistent with the ship being able to fulfil its economic purpose, hence the attitude towards timber, furnishings and combustible decorations.

The remarks concerning asbestos underwear could hardly be passed over. With great deference to Colonel Bates, when he donned his winter-weight woollies he had gone a considerable way towards satisfying the demands of the fire protection world.

The advocates of the elimination of wood and combustible finishes were really most seriously concerned with the rapid spread of fire which these finishes encouraged. But many British ships, including those of Colonel Bates's company, took care of this by the installation of automatic sprinklers.

With regard to the personal fire risk, efforts were being made in various places to encourage people not to wear highly combustible clothing, but it had not been suggested yet that little girls' nighties should be made of asbestos!

With regard to marking the method of operation on extinguishers, he would like to go one better than Mr. Wray and to suggest that Mr. Welch and Colonel Bates might draw up a specification of the extinguisher they would like to have and the method of marking and present it to extinguisher manufacturers, and refuse to buy any other. He was sure if one sufficiently large organization or company were to insist on standardization throughout their organization this would carry more weight with the manufacturers than any exhortations, which had failed.

MR. E. G. WEST, Ph.D., B.Sc., said that he would like to bring the discussion back to a matter which naval architects had been considering for a long time, namely, the effect of fires on aluminium structures.

The increasing use of aluminium, particularly for stressed superstructures, its potential use for bulkheads, and its present-day use for masts, funnels and a great many items, had brought the possible extension of fire risks, due to its lower melting point, into prominence.

The work carried out by Dr. Corlett and Mr. Venus which was mentioned in the paper by Mr. Clarke and Mr. Hodges, had been intended to provide guidance to the naval architect on the protective measures which could be taken in order that aluminium structures should not present any greater risk of structural collapse than the more familiar and accepted steel structures.

The difference was one of relatively small degree and he was encouraged to think that that view was beginning to be accepted by many of the authorities concerned.

It was, of course, true that the melting point of aluminium at about 650 deg. C. was half that of steel; but this was not the only criterion. The major factor was the loss of structural strength in the material as the temperature increased, and taking the standard fire—and he was sure only the standard fire could be used for such calculations—the rate of loss of strength of aluminium was such that a stressed column would collapse in the first 2½ minutes. The increase in temperature was such that after another 2½ minutes the loss of strength of a comparable steel column would be such that collapse would then take place.

The naval architect was concerned, therefore, with providing insulation or other means of protection which would do the job as between 2½ minutes for aluminium and 5 minutes for steel. Furthermore, consideration must be given—and it might apply in several ways—to the very much higher thermal conductivity of aluminium compared with steel. Aluminium might conduct heat away from the seat of the fire so rapidly that the temperature of the metal did not reach a dangerous level. On the other hand, it might conduct the heat away to a site where it was not wanted.

He had really come to the symposium to learn the views of the naval architects and those responsible for running ships as to their current views on the application of aluminium and the means of insulation which would be required in various positions. The work which had been reported went a long way towards a solution but if there were still problems he would welcome discussion of them so that the necessary work could be put in hand through Mr. Clarke and his organization to find the answers to these questions.

MR. J. BROWN, B.Sc., said that his remarks related to the papers by Colonel Bates and Mr. Clarke and Mr. Hodges.

He would like to endorse most vigorously Colonel Bates's statement about the psychological danger of fostering the concept of the fireproof ship. It could not be achieved. He could not accept the suggestion made by an earlier speaker that if the concept of the fireproof ship was not accepted one was driven to the opposite extreme. That was not so. One was driven to use *every* possible means of detecting and controlling inevitable fires.

In passenger ships one of the most effective means was the automatic sprinkler, and the British view of this feature was a sound one. It had the dual property of being a means of detection and extinction.

The great advantage of the sprinkler was that it gave a means of reducing the fire potential and preventing an actual fire load from developing. No one should be alarmed by this term, "fire potential". It *was* a potential and not a load. Given some means of control, it should not be allowed to develop into a load.

From the shipbuilder's point of view there was a feature of sprinkler systems which was of considerable value in the construction of passenger ships. With suitable organization such a system could be brought into use during the building of a ship at an early stage before much of the fire potential was built into the ship. There would then be a measure of safety during the building period which was of some value, as the insurance members of the audience would, he thought, concede.

Support for the automatic sprinkler should not be taken to indicate lack of sympathy with other methods of containing or preventing the spread of fire. The use of incombustible boards as bulkheading or ceiling panels to provide fire-resistant zones and of suitable fire-resisting insulation was essential to the successful fire "treatment" of any passenger ship, confirming the remark above that use should be made of *every* possible means.

With regard to the paper by Mr. Clarke and Mr. Hodges, he would like to express his appreciation of the opportunity to speak at the symposium. He had the privilege of being a shipbuilder member of the Fire Research Board associated with the Fire Research Station and had been somewhat awed by the amount of work that went on in this field. It was not generally known, he thought, to shipbuilders or marine engineers.

He was at liberty to say that the Fire Research Station would welcome enquiries from either the Institute of Marine Engineers or the Institution of Naval Architects. It had a fund of knowledge in land fires which must be of value in considering ship fires.

Mr. Clarke and Mr. Hodges had touched very briefly in their paper on stability and the gathering of water on decks. A valuable piece of work was done some years ago in Glasgow at the instigation of Mr. Chadwick, the Firemaster of Glasgow Corporation Fire Department, who was referred to in the paper. He made the request that information should be made available to the fire service in Glasgow about the effect on a ship of the admission of large quantities of water. In other words, he was worried about the stability of ships when he was fire fighting.

One of his (Mr. Brown's) assistants went into the matter very ably and prepared an excellent paper. Through Mr. Chadwick the co-operation of the Admiralty was obtained and they loaned a teaching film used by them in damage control work. This was worked up into an excellent presentation of the problem of stability in relation to fire fighting. Large attendances from the fire fighting services of the area resulted, and it was a most effective and useful exercise. There was a large number of fire officers present at the symposium, and he might be preaching to the converted; but if they had not had such a study made, it would be worth contacting some of the local people in their own district, who might be prepared to offer similar assistance.

Mr. S. D. Sohoni (Associate Member, I.Mar.E. and I.N.A.), whose contribution was read in his absence by Mr. R. D. Raje, said that he would like to congratulate the authors on the excellent papers they had submitted, but there were some points that required clarification.

The development of the inert gas generator, as installed on the m.v. *Oti* of the Elder Dempster Lines, has been hailed by the press and the leading authorities as the most significant development of the twentieth century in fire fighting technique. He understood from reliable published data that it took about half-an-hour to bring down the oxygen content of an average hold to 12·5 per cent, which was essential to prevent combustion and re-ignition. This was radically slow as compared with the usual methods applied at present. Moreover, there were a number of possibilities of failure in the unit, such as the failure of the Diesel engine, the oil-burning unit or the water circulation unit. With all these factors of failure, could one be certain of the positive supply and prompt application of inert gas in an emergency? In his opinion, it was essential that this method should be supplemented by a CO_2 battery system or a dry powder charge separately for each hold. A gas generator on its own was unlikely to be popular at sea.

He was in complete agreement with the author regarding the operational instructions for fire extinguishers on ships, but very often these appliances were placed in an awkward position which was apt to go unnoticed and thereby they were rendered useless. Would it not be proper to locate the fire extinguishers in the most conspicuous position? As for cleanliness and the spotting of oil leaks, it would be a good suggestion to use white or aluminium paint for fuel tank and tank tops. This would help to spot the leaks easily, apart from improving the general appearance of machinery spaces.

On page 475 it was stated that "The study of reports suggests that it is frequently the failure of the fire fighters and not the lack of equipment which results in serious fires. . . . .". In his opinion, the cause of this was unjustly attributed to the fire fighter. The performances of any fire fighting body depended on the kind of training received. Those responsible for organizing an efficient fire fighting party had utterly failed to realize the value of regular fire drills. In a number of ships a fire drill was treated as another Ministry of Transport sport on Saturdays, No. 2 hatch being the usual meeting place. In fact, in one ship when the fire alarm was given most of the crew rushed to No. 2 hatch by force of habit, when the actual fire was elsewhere. Could the authors suggest any means of making these fire drills at sea more exciting and realistic, so as to make the average seaman realize the gravity of the situation?

He had only one point to make on the paper by Colonel Bates. On page 480, the author described how the crew as a single entity fulfilled the desired purpose of fire fighting at sea, but the same combination under port environment showed signs of weakening. What was the reason for this? Think logically and the answer was simple and straightforward. Imagine one was on a burning hulk, slowly sinking. The position was worse than that of a mouse in a trap who could at least escape if the trap was opened. For a sailor there was only Hobson's choice. If he stepped off the ship, he was a welcome feed for the sharks or faced slow death by drowning. In these circumstances, was it any wonder if everyone gave his star performance? In port, conditions were different. If the worst came to the worst, he could step off and join another ship. The average shore worker had no love for the ship and it was but natural if he adopted an attitude of "couldn't care less".

Finally, all the papers served to remind one that there was no such thing as a perfectly fireproof ship. He would appreciate Colonel Bates's agreement that "Man is a superior animal", in two ways; he could make fire and make love round the year, both being necessary for his existence, and if he could make fire efficiently, he could also extinguish it still more efficiently.

Mr. N. Mear, A.M.I.Mech.E., A.M.Inst.Gas E., said that he had some diffidence in speaking because his first experience with seagoing fire fighting was in connexion with the inert gas generator of the m.v. *Oti*. He had had some experience with inert gas on land, however, and might therefore be able to make a few remarks of interest.

He had not seen in Mr. Welch's paper any reference to fires on board oil tankers. He would like to know whether there were no fires to report or whether they were purposely omitted. Oil tankers would seem to present a hazard similar to hazards he had met ashore, particularly in the gas industry, where large vessels were often filled and emptied of explosive and inflammable materials. In an oil tanker the spaces from which the oil was discharged were subsequently filled with air, which was drawn in as the oil left. In those spaces there must be a mixture of inflammable gas and air which at times must be in an explosive condition. A supply of inert gas on board the tanker would go a long way to avoid this risk. Inert gas could be fed into the hold as the oil was withdrawn. Thus at no time could air be drawn in to mix with inflammable vapours, and the possibility of an explosion would be considerably reduced.

There was also the possibility of using inert gas for blanketing continuously the surfaces of the oil spaces and the cofferdams in oil tankers so as to prevent any possibility of explosive mixtures developing in those spaces while the ship was at sea.

Reference had been made to the use of inert gas for fighting fires in cargo holds in port and to the possibility of using portable inert gas generators for that purpose. Such equipment was in existence and was widely used in the gas industry for similar purposes, primarily for fire prevention but also for fire extinction. Portable equipment was available in sizes comparable with that fitted on board the m.v. *Oti.*

The tests aboard the *Phobos* were remarkable in that the capacity of the inert gas generator used was only 500 cu. ft. per hr. and that this very small generator was used for extinguishing actual fires in a hold which had a volume of 60,000 cu. ft. The Ministry requirements for a space of that size would be 15,000 cu. ft. per hr., so in the *Phobos* the fires were put out with a generator of 500 cu. ft. per hr. capacity, which was only one-thirtieth of the size recommended by the Ministry of Transport. An interesting feature about the results was that when the ship was battened down the combustion inside the holds proceeded and by itself reduced the oxygen content considerably. But from his reading of the reports this could never be reduced to the point at which combustion would cease; the fire would not go out, owing to the continuous in-drawing of air which continued to support combustion. The tests showed that a small supply of inert gas continuously applied was sufficient, when added to the consumption of oxygen by the fire internally, to extinguish the fire finally. Even a small amount of inert gas continuously injected for this purpose in a well sealed hold would finally extinguish the fire.

That point was proved aboard the *Phobos*. Therefore, with the recommendations of the Ministry of Transport as regards capacity there should be a considerable margin of safety for any hold that was reasonably well battened down.

Questions had been asked about the starting up and availability of the equipment. This class of equipment was an assembly of parts which were not unfamiliar to the marine engineer. It comprised a marine Diesel engine, an air blower of the supercharging type as fitted to Diesel engines, oil-burning equipment, and cooling equipment. Availability could be ensured satisfactorily by the fact that it could be operated at any time and as frequently as anyone might desire.

With CO_2 equipment it was not possible to open the bottles to see if the gas went in the right spaces. That had to be left until the time when the emergency arose, but with inert gas equipment a plant could be operated as often as necessary to ensure that the personnel who would have to operate it were familiar with its operation.

LT.-CDR. M. B. F. RANKEN, R.N., said that he was serving in a ship largely constructed of aluminium and containing a lot of aluminium furniture. He would like to mention one or two points which had arisen, not only as regards that, but also in dealing with a serious fire that occurred some time ago.

Colonel Bates was pessimistic about changing furniture and so forth to metal. Aluminum chests of drawers, desks, etc., and fittings, such as doors, door frames, bunk seatings and so on, which were not so visible, were just as good as wood and could be made to look as attractive. Mr. Carter would bear out that the vast majority of ships fitted out by the Navy since the war were so constructed, though there was still a tendency for many dockyard men to put in wood if they were not closely watched. Very often aluminium could be used with a little care and ingenuity without detracting from the appearance.

The insulation of electric cables had been mentioned. He hoped that lead-covered cables were on their way out, as they were a considerable problem when they got hot in a fire.

Mr. Welch seemed to be against steam drenching from the point of view of watertube boilers not having a large steam reservoir. On the other hand, for machinery space fires he himself was sure there was considerable benefit.

Everyone knew that foam could be extremely efficient when the fire could be reached, but there was a big problem in confined spaces, particularly in a boiler room where there were drip trays and so on under the registers which were well above the bilge. It was all right getting in at the beginning when the fire was small with a two-gallon extinguisher, preferably with a short hose on it, but once one had to fight the fire from outside the compartment, the foam went down into the bilge and presumably if the bilge were not dry initially, there was a danger of feeding the fire with any oil present when the level was raised sufficiently.

He might be very ignorant or talking nonsense, but he wondered why sand was so rigorously objected to nowadays. It was undoubtedly very useful for smothering a small fire and also because of its absorptive properties. He knew it was a sabotage risk in H.M. ships and possibly merchant ships as well, but he had seen it used effectively.

Probably the most crucial requirement in smothering was to close all ventilation and other openings to the compartment concerned. While this might be fairly easy in cargo spaces, it certainly was not in the machinery spaces of merchant ships. In this respect the smaller and entirely separate machinery spaces of warships were attractive, though the accesses to the bottoms of the compartments were lacking and made it necessary—and difficult—to attack all large fires from above. Many ships were saved during the war by good watertight integrity and the air pressure testing of compartments for this purpose also served to ensure air tightness for fire fighting.

It would certainly be a great advance in warships when combined hull and fire pumps were eliminated. Air pumps were an abomination, and nothing wore out a pump more quickly than running it dry. The position was aggravated in many small ships because the suction line ran more than fifteen feet above the bilges from which suction was to be taken. This was near the top of the machinery spaces, and, apart from the difficulty of obtaining a suction, it was also the hottest point. In one fire he fought, this resulted in the rubber joints being burned and prevented any water used for fire fighting from being pumped out again to safeguard stability.

Pumping capacity was most important, but several small pumps in or near the spaces where they were to be used were preferable to a few of larger size. Most small ships had three pumps. In one fire he fought they were reduced to one pump, and that was required both for fire fighting and for suction purposes.

While power was always liable to be lost, electric portable pumps were at present the only practical ones for use between decks, and the submersible types were of great use, even though they were liable to failure by flooding. This should be overcome when all ships had alternating current throughout.

He could only describe the Diesel portable pump as a "white elephant" in its present form. While it could usually be made to run, it must often be mounted so high above the sea that an adequate suction was hard to obtain. The provision of a portable Diesel generator might be more useful, in conjunction with more electric portable pumps, though there was a lot to be said for the fixed Diesel pump fitted below the tonnage hatch in so many merchant ships.

Much had been said in the papers about human failures and the need for good training. Everyone tended to think of fires as somebody else's worry and as being most unlikely to happen to them. Unfortunately, the only really good fireman was the one who had had to fight fires before, and this in the present case implied ship fires which no one wanted. The best alternative to bitter experience was the excellent courses which were available ashore. These at least gave confidence in the available equipment and drew attention to many of the snags and other things to be avoided.

An excellent training film entitled "The Chemistry of Fire" was produced over fifteen years ago by the U.S. Navy. Part I reduced the whole subject to basic principles by likening fire to a triangle, the three sides of which represented combustible material, heat and oxygen. If any one side was missing, the fire could not burn, and all successful fire prevention and fire fighting aimed at keeping or making the triangle incomplete.

Captain Hogger had already mentioned "The Ship Fire Fighting Manual", which was issued as a book of reference for the Navy. The Admiralty might consider releasing it for sale to all seafaring men.

Films and books were not in themselves sufficient and, regrettably, human nature was such that few took the trouble to become intimate with fire fighting until it was forced upon them by actual experience. The only alternative to voluntary study was compulsory examination and frequent exercise; no seaman, of whatever branch or grade, should ever be given promotion or advancement without a really searching examination in damage control; that was to say, ship knowledge, fire fighting, stability and damage repair and counter measures. This was included in ratings' examinations in the Navy, though what was asked depended on the examiner. If it was not already, it should also be given prominence in all Ministry of Transport examinations.

Damage control was very much a part of "seamanship" in its broadest sense, and it should not be treated as a disagreeable and separate subject. Fire fighting must be undertaken by all personnel, and it was most important that it should not be tackled on a departmental basis.

Considerable mention had been made in the papers of co-operation with the shore fire brigades when in home or foreign ports. This, of course, was most important and might be essential. In the case of the Royal Dockyards there was a standing procedure by which all fires were reported to the Dockyard Fire Station, who in turn automatically informed the local county or city fire brigade. That this sometimes resulted in too many fire engines and firemen arriving for a small fire was unimportant, as it gave the shore brigades an opportunity of going on board ships and becoming familiar with the special problems involved. Shore brigades in or near seaports should always be trained in ship fire fighting. It was, however, his opinion that a senior ship's officer should always direct operations in the light of his intimate knowledge of the ship, and so avoid the excessive and dangerous use of water.

The need for special care in port was realized by most firms, and ship repairers usually had watchmen in empty ships, and their own firemen in addition, to supervize welding and other operations involving fire risks. Of course, the ultimate ideal was reached in the *Queen Mary* and the *Queen Elizabeth,* with their own ship's firemen, fire station, and extremely strict regulations, including frequent rounds by a responsible officer.

Finally, he would like to describe a serious fire which occurred in his last ship as it illustrated a number of important points and showed what could happen if a fire was not attacked correctly and expeditiously from the very beginning.

The fire started at about three o'clock in the morning in No. 1 boiler room of a wartime-built destroyer conversion. An accumulation of hot oil collected in the drip trays below the registers of an Admiralty three-drum boiler with enclosed front, and was due to the very excessive build-up of carbon on one brick-lined quarl over a considerable period. This in itself was extremely bad watchkeeping.

When the fire was noticed it was burning fiercely, but it was still under control and should have been subdued with two-gallon foam extinguishers. Although four such extinguishers were used, it was found afterwards that none had been fully expended, and it was clear that they had not been used correctly or promptly.

The fire was now worse but could still have been controlled without doing any damage. At this juncture the petty officer of the watch decided to shut down the boiler and thereby made it imperative to evacuate the boiler room. He correctly shut off all sprayers and the oil fuel pump and heater, leaving the feed pump running, but he also stopped the forced draught fan and shut all the air shut-off tubes. It was instinctive to shut off air to a fire, but this should not be done until the last minute in a closed stokehold, as the fire was under pressure and stopping the fan released the pressure and allowed the fire to expand. In this case the fire obtained air from the lower casings under the boiler and some from the funnel via the furnace and leakage round the air shut-off tubes. It then spread rapidly along the drip trays and upwards through the two side air casings until flames were issuing from the back of the boiler on to the adjacent bulkhead.

At this stage the boiler room filled with thick smoke and became untenable. The watchkeepers evacuated and all accesses were shut down and the steam drenchers were turned on, using the remaining steam in the boiler. Foam was introduced a little later with the aid of a dockyard fire engine. For the reasons already given, attempts to get the only available hull and fire pump to pick up a suction and keep the level down in the boiler room bilge were unsuccessful.

The fire burned for two hours and its fierceness could be gauged from the fact that the after bulkhead was nearly red hot and distorted, the deck head was too hot to stand on, a telegraph shaft brass coupling was melted, £2,000 worth of electric cables, mainly lead-cased, were damaged or burnt out, and a lubricating oil tank was still bubbling some hours after the fire had been extinguished.

It was interesting that there was no appreciable damage to the boiler itself, and steam was raised in it again the same day. The ship went to sea as planned soon after the fire was out, but on the other boiler.

The lessons of this fire were the need for really detailed training and frequent exercising in fire prevention and fighting, particularly in the first-aid appliances; and in this case the point he wanted to bring out most was that the air should not be shut off until the fire was beyond control from within the compartment, because it got out of hand immediately the pressure was released.

Captain Hogger might consider whether the difficulty of hot oil from leakage accumulating in such a hot place just below the boiler registers could not be overcome.

MR. A. AUDIGÉ after thanking the Institute for the invitation to attend the symposium, said he had some remarks to make on the interesting paper by Mr. Clarke and Mr. Hodges. The meeting might like to have some information, he thought, about the latest French regulations against fire and for the reduction of the amount of combustible material in ships.

There was, in France, a general trend towards incombustible or non-flammable materials, in the light of the methods developed in Great Britain by the Fire Research Station, in accordance with the principles that had been outlined at the morning session.

The three official methods laid down by the London Convention in 1948 were adopted with slight modifications and some complementary restrictions, a compromise being reached between safety and economic factors. In fact, French shipowners in general favoured Method III but they also adopted Method II, and in some parts of their ships applied Method I. For Methods I and III chiefly, they tried to take steps to reduce combustible materials.

Method I was based on "incombustible bulkheads", but an interesting development was to reduce the amount of combustible material within these incombustible bulkheads and according to the American practice an "incombustible room" was defined as follows:

> "An incombustible room is a room where the total amount of combustible materials used for bulkheads, ceilings, linings and fixed furniture does not exceed 4 kg/m^2 0·83lb./sq. ft.".

In Method III the Convention provided for a reduction in combustible materials but its extent was left "to the discretion of the national administrations". In France attention had been given to bulkheads, deck coverings and ceilings. He must stress that, for research and merchant marine regulations, the British classification of materials had been adopted in France, according to principles referred to in the paper by Mr.

Clarke and Mr. Hodges. A special radiant furnace had been put into service for this purpose.

For bulkheads, in corridors, halls and stairs, surface spread of flame test Class 2 was required for Method III (Class 1 in Method I).

"The concealed surfaces of linings, bulkheads, grounds, backings and decorations shall be of low spread of flame Class 2" (both for normal partition bulkhead and for fire bulkheads).

For cabins, Class 3 (medium grade) was permitted (Method I and III): Class 4 was not permitted anywhere.

For deck coverings, Class 2 was required (rubber, tiles, etc.) with the exception that Class 3 was acceptable if the underlay was incombustible.

For ceilings, there was some relaxation in the partition rule from deck to deck if the ceiling were incombustible; the use of this kind of ceiling was compulsory if the ventilation openings had been provided in the upper part of the corridor bulkheads.

The new regulations recommended other precautions: "The use of flammable materials for curtains, decorations and furniture shall be reduced, as much as possible, in accommodation and service spaces".

"It is recommended that the furniture for halls, corridors, stairs, kitchens, control stations, and stores, should be made of materials of low flammability".

"Light furniture textiles should be given a fire-retardant treatment, as should mattresses, coverings and carpets of vegetable fibre (i.e. other than wool)".

"Everywhere preference shall be given to incombustible insulating materials. Cork is not allowed for conditioned air conduits unless sheathed with non-flammable material; ganulated cork of less than ¼ inch is not allowed".

"The large public spaces shall have A bulkheads with incombustible grounds and backings".

"The vertical ventilation ducts shall be incombustible as well as the passages through all fire bulkheads A and B".

A reduction in the amount of combustible material implied in France a corresponding reduction in the installation of bulkheads, and here some tables had been drawn up for shipbuilders and shipowners, in extension of the rules of the three methods. The object was to encourage them always to use the less flammable materials or incombustible materials. In this field certain difficulties had been encountered in classifying new plastics, such as PVC, polystyrene, resin-bonded paper, fibre glass, polyester bonded material, and so on. The risk of fire might be substantial in some cases but could be ignored in others. He was not sure the classification of flammable products now adopted reflected correctly the hazards involved. This remark also applied to incombustibility tests. He would be interested to hear the views of the authors on these difficult points.

For the future it would be necessary to revise the present rules in accordance with the progress and economic possibilities of new materials. This was no longer 1948 and allowance had to be made for new processes and new materials.

In conclusion, he hoped that the whole question would be dealt with in the future in a spirit of practical international co-operation such as was shown at the London Convention of 1948.

MR. I. S. B. WILSON (Member) asked whether it would be possible to inject an irritant into CO_2 gas. A serious fire at sea could necessitate evacuation of the engine room and the flooding of that compartment with CO_2. With the engine room out of action the vessel would become a floating hull without power or steerage. The danger of wrecking and dealing with large volumes of water used in the initial stages of the fire, cooling bulkheads, etc., would require engineers to return to the engine room as soon as possible.

With CO_2 flooding it would be very difficult to clear the engine room of this gas, particularly under floor plates, in bilges, etc., where engineers would undoubtedly have to effect emergency repairs. If this gas incorporated a stenching agent this would act as a warning to the engineer and he could take necessary steps regarding further ventilation.

Correspondence

MR. B. P. ARROWSMITH, O.B.E. (Member, I.Mar.E.) wrote that many of the opinions he expressed were coloured by his company's attitude as owners of refrigerated cargo vessels which had, in his view, a strong claim to be regarded as a specialized class of shipping. In reading through Mr. Welch's most comprehensive paper he was reminded that a serious fire in such a vessel might present additional hazards and would need to be attacked in a somewhat different manner than if she were a general freighter.

Until recent years cork was the standard material for insulation. This substance would not only ignite by indirect heat but would moreover smoulder fiercely in confined spaces independent of an external air supply. The cork, in granulated form, was enclosed by sheathing which a smothering medium could not penetrate. In a loaded compartment a fire of this type would almost certainly call for nothing less than total flooding.

With the advent of a non-combustible insulating material this danger had been minimized. His company's sentiments on the subject were so strong that they had undertaken an extensive programme of replacement in older vessels. However, there must be much cork insulation still in service and it was suggested that fires in this category (although not strictly a primary cause) would be of sufficient interest to merit a separate heading in Mr. Welch's Table No. I.

He would like to make it clear that the flooding of a loaded refrigerated hold might be subject to complications because such a compartment could have no ventilators in the usual sense of the word. Unless special provision had been made it would be necessary to discharge cargo in order to gain access.

Mr. Welch's opinion on the use of fire-retardant and metallic paints would be much appreciated.

In one outbreak, fire was noted to have spread along the route of cable trays. The main cause of this was the traces of oil that accumulated behind the trays where it was inaccessible for cleaning. Design and construction might then do their part in helping the engine room staff to maintain that essential cleanliness.

Provision should be made for a fire fighting party to attack via the shaft tunnel. Mr. Welch referred to the value of a fireproof door; there should also be a fire main direct from the auxiliary pump so that a hydrant might be placed near to the engine room bulkhead.

The consequences of drenching electrical equipment should be firmly emphasized. In many circumstances this action might result in a completely "dead" ship in a position of grave navigational danger.

The use of compressed air breathing apparatus had proved to be most successful. For full efficiency two outfits were necessary, both for the purpose of handling hoses, etc., and for reconnaissance when it was necessary to accompany an inexperienced person. In the case of prolonged operations the problem of recharging cylinders might present difficulties. The ideal solution, of course, would be to have a convenient type of compressor for use on board ship.

Since loss of stability was partly dependent on the area of free water, there might be occasions when drainage could result in a worsened condition, as could be caused, for example, by the overflow of a bilge. Draining away surplus water was not, therefore, an operation to be carried out without due regard for the consequences.

In connexion with Colonel Bates's paper, one of the most important steps in fire protection was, to his mind, the training of responsible officers at H.M.S. *Phœnix* and the Liverpool Fire Fighting School. He would like to record his company's appreciation of their efficient training: of the co-operation of the Royal Navy and the initiative of the organizers of the Liverpool School. It was most heartening to see the enthusiasm generated in all who attended the three-day course.

However well trained the officers and however well equipped the ship, it was still vital to make an early call on the Fire Service. It was disappointing then to note that ship communications in port might be far from good. He had on record an occasion when at least twenty minutes would have been required to contact the Fire Brigade.

Colonel Bates's description of quiet efficiency recalled the shipboard tendency to keep quiet in emergencies, thus preventing undue alarm, particularly amongst passengers. It was important then that there must be some immediate and unmistakable signal to alert all who might be concerned. The situation was particularly acute in an engine room fire. Those on the spot were engrossed and needed speedy help from their colleagues; the deck party must stand by to close down and the Bridge to assess the navigational position. All that the hard-pressed engineer officer could spare was a second to close the switch of a signal circuit.

It was noted with interest that the Royal Navy had adopted CO_2 for many purposes. The small CO_2 extinguisher was probably the best for electrical fires, except that a merchant vessel, so long away from home port, would have difficulty in readily recharging such extinguishers. This problem had aspects in common with that of refilling compressed air cylinders. It would be interesting to know if the Royal Navy had devised a compressor or some other means of accomplishing this without aid from shore.

Although the use of standard hose couplings was now widespread there still remained the question of connecting to a variety of hydrants and to the many older types of coupling still in use.

These difficulties of adaptation could be overcome by making this "standard flange" an accessory to all hose outfits.

In reading the paper on research, and the symposium generally, one was impressed by the wealth of information so well presented. Much of this information was vital to those on whom so much depended—the responsible officers on deck and in the engine room. All data, of course, were duly published but so often they appeared in a journal which was not readily available to those engaged in foreign going trade. Should they not then ensure that information about technical developments, experience of ship fires, etc., was published in a form (perhaps as an annual supplement to some suitable periodical) most likely to attract the attention of senior navigating and engineer officers?

MR. F. BARBER wished, first of all, to congratulate the authors of the papers. They constituted an enormous amount of work and covered the field very thoroughly indeed.

Coming to details, there was a comment on the use of liquid CO_2, that was, CO_2 stored in cylinders, for use in the type of oil fire met in ships' engine and boiler rooms.

His company had recently had the opportunity of witnessing a test on a system which was designed to discharge 2,370lb. CO_2 through two ¾in. pipes. This system took about four minutes to discharge 75 per cent of its contents, the remaining 25 per cent taking about another four to five minutes. The Ministry of Transport requirements were that "the pipe sizes and nozzle arrangements should allow the whole charge of gas to enter the space in not more than about two minutes".*

He regretted to note an increase, particularly on the Continent, in the number of so-called engine and boiler room total flooding systems which were installed with completely inadequate piping. This gave the owner a false sense of security and could well condemn a sound basic practice owing to faulty application.

The accepted pipe sizes for CO_2 discharges of this type, both here and in the U.S.A., were as follows:—

Maximum quantity of CO_2 required, lb.	*Minimum nominal pipe sizes, in.*
200	¾
300	1
600	1¼
1,000	1½
2,450	2
2,500	2½
4,450	3
7,100	3½

A considerable number of tests carried out recently confirmed these sizes; for instance, the maximum rate at which CO_2 could be discharged through a ¾in. pipe was about 4lb. per second, and this only for about 75 per cent of the contents of the cylinders.

Turning to crankcase explosions, his company had done a considerable amount of work during the last five years on this question, with the idea of detecting the "condensed oil mist", which was the basic cause of crankcase explosions, before it attained a sufficient concentration to become explosive.

Such a system had many snags which required long experience with light sensitive devices as applied to marine use, but with proper precautions to look after voltage variations, dirt accumulation, and the other evils which beset those who played with this type of equipment, they found they could give an alarm when the concentration of the mist was about 1/300 of the explosive minimum and, at the same time, provide a robust and reliable instrument. Such an instrument had already had successful sea trials over many months and was approved by the Ministry of Transport.

Reference had been made to a radioactive method of checking the contents of CO_2 cylinders. An initial difficulty was to keep the gamma-ray source, radiation detector, and head amplifier sufficiently small to be useful in existing, closely-stowed cylinder banks. The problem had now been solved by development of a probe which was less than one inch in diameter and could readily be inserted to check all cylinders, even when they were stowed four deep. This apparatus had now been in successful use for some time and fully substantiated Mr. Welch's suggestions regarding labour saving.

MR. R. BEATTIE (Member, I.Mar.E.) considered that the symposium was of prime importance to those connected with the industry both ashore and afloat and the authors of the papers obviously had given a great deal of time and study to their preparation. The subject was a vast one considering the nature of the problems which arose owing to the variety and types of craft afloat today. He would like to make it perfectly clear that his knowledge in relation to the larger type of vessel was strictly limited to the reading of the various text-books, reports and recommendations made by others in connexion with fire prevention, fire fighting, etc., and he was not therefore in a position to enter into a discussion on this class of vessel.

* Ministry of Transport and Civil Aviation Survey of Fire Appliances, Instructions to Surveyors, para. 37.

It would appear that the bulk of fires taking place in ships today were in vessels which were in port, discharging or under repair. The introduction of new methods of construction and repair (here he referred principally to welding and burning) were responsible for at least 65 per cent of the fires occurring in shipyards and repair berths, whereas at sea the main causes of engine room fires seemed to be overflowing tanks, leakages from pipe joints and carelessness in maintaining the strictest cleanliness in oil fuel units. This also applied to the exhaust systems in Diesel engines.

Although there had been a big improvement in supervision and fire watching during burning and welding repairs, there was still room for improvement in this direction and no room for complacency, especially in the availability of fire fighting equipment. Smoking no doubt accounted largely for the balance and he would put the figure due to this cause in the region of 15 per cent, allowing about 20 per cent to other causes such as open electric radiators, stoves, etc.

It often happens that a bracket or deck fitting in way of accommodation has to be removed for access or repair. To save delay the tradesman concerned calls for a burner to cut out the bolts without first making sure that there is no danger of sparks setting alight any combustible material that may be in the vicinity. Many minor fires owe their origin to this indifference towards standing orders in relation to burning and welding.

There is a surprising lack of trained personnel at sea today, perhaps not so much in the passenger and cargo liner class, which after all represent a very small proportion of vessels registered under the British Flag. When one reflected on the number of vessels between 7,000 and 10,000 gross tons which were sailing with personnel in charge of the machinery who, apart from the chief and second engineers, were uncertificated (the position was even more serious in the 500 to 2,000 gross tons class), surely the emphasis should be to develop fire fighting appliances along the simplest lines commensurate with efficiency. There was no doubt that for engine and boiler room spaces the standard two-gallon foam extinguishers had been very effective when used intelligently and immediately a fire had started. This, backed up with at least one thirty-gallon extinguisher, dependent on the size of the ship and space available, with suitable length of hose attached, could be most effective when handled by an efficient staff.

During the war years he had under his charge a twin-screw vessel of roughly 800 gross tons which had a most unusual boiler room arrangement. The vessel had two separate boiler rooms, both operated on the closed stokehold, forced draught system and completely isolated from each other. No. 1 boiler room (next to the engine room) was entered by an air lock with interlocking doors. This boiler room contained an oil-fired watertube boiler complete with independent feed pumps and automatic regulator. No. 2 boiler room contained a three-furnace Scotch marine-type boiler, coal fired. On a passage from the Clyde to Oban, the chief engineer (certificated) by some means which never had been satisfactorily explained, managed to open both doors of the air lock at the same time, thereby causing a collapse of the air pressure in the stokehold. The direct result of this collapse was an exceptionally heavy blow-back which set fire to an excess of oil collected in the fairly large save-alls below the burners. The intensity of the fire was such that it made it impossible for the personnel to tackle the fire from the floor level of the boiler room. The chief engineer, who had been fairly badly burned, managed with assistance to get to the foam hopper in the 'tween deck, where he was successful in getting this valuable piece of equipment into operation. After using the entire stock of foam powder he still had not brought the fire under control. Fortunately, at this stage the second engineer, who was uncertificated, arrived in the engine room, took in the situation at a glance, realized that the seat of the fire was above the plates and the foam which now had almost reached the top of the floors was still a long way from the floor plates, promptly connected the engine room fire hose and using the jet nozzle directed it into the save-alls, washing the burning oil out and into the bilges where the foam effectively blanketed the flames. The severity of this fire can be judged by the fact that all brass mountings on the boiler front had melted and the casing, bulkheads and uptakes were extensively damaged through overheating, the plates buckling under the intense heat.

He mentioned this case in particular as it reiterated what had been clearly stated throughout this symposium, the failure of the human element, and also bore out Mr. Welch's statement in the last paragraph of page 475, at the foot of column two, that foam was most effective even if it were below the level of the seat of the fire. He would like to point out that the second engineer in this instance had received fire fighting training in the Auxiliary Fire Service before going back to sea and there was no doubt that his handling of the situation and prompt action saved what might have been a disaster.

Another instance of fire at sea which might have had disastrous consequences was caused by the placing of pyrotechnic signals in a locker below the companionway leading to the saloon. Close to the casing of this locker was an ornamental, slow combustion heating stove. The stove pipe was separated from the woodwork by an asbestos panel. This had become damaged and the heat from the overstoked stove caused the locker woodwork to start smouldering. The result was that either a distress rocket or a hand flare ignited, setting fire to the saloon, which was soon a blazing mass. Fortunately neither the master nor chief officer were in their rooms (which were off the saloon) at the time. It was impossible to tackle the fire from the saloon entrance stairway, but prompt action in breaking sidelight glasses enabled the crew to fight the fire with a double set of hoses, eventually bringing it under control and extinguishing it.

He mentioned this particular instance as it was the third fire in vessels with which he had been connected in the past seven years caused by pyrotechnic signals being stored in an unsuitable locker.

Another vulnerable item of L.S.A. gear was the kapok-filled lifejacket. Here a carelessly dropped cigarette could cause an immediate conflagration which in one case of recent origin resulted in considerable damage in the passenger accommodation of the vessel concerned.

Now with regard to the control of ventilation, it was emphasized throughout this discussion that the prevention of air passing from the compartment where the fire had originated was one of the most difficult problems confronting those responsible for the design of ventilating equipment. Air-conditioning was used extensively in modern construction, applying equally to the largest and smallest vessels. The fitting of isolation flaps to the ducting was open to argument, yet it was desirable that some means be made available to cut out the air supply to any one particular compartment other than by closing the supply at the main air intake. In his opinion it would be an advantage to divide the various compartments into separate units working from independent air intakes. Unfortunately, this meant additional deck fittings in the form of vents, etc., and the decks of modern vessels were restricted enough without adding obstructions. He was quite sure this problem could be overcome with some ingenuity. In recent years there had been progress in the design of suitable ventilator heads. He had introduced a head which had several advantages over the orthodox types. It was completely fire- and gas-proof, having a sealing of neoprene rubber. The smaller types could be operated by hand and the larger types by means of quick-operating screws. They were particularly suitable for tanker pump rooms and MacGregor hatches, quite a number having been fitted already to tanker and cargo ships built and building in this country. They completely eliminated the use of wooden plugs and canvas covers and the removal of ventilator heads to fit them. No flaps or butterfly shut-offs in trunking were required and, being rotatable, they could be turned off-wind if desired. The long alleyways and large passages in the larger vessels acted more or less in the nature of funnels drawing the air to the seat of the fire and thereby extending the outbreak. The proposal to have fireproof screens fitted at intervals in long alleyways, etc., similar to those used in mines, was an excellent suggestion and could prove most useful in some types of outbreak.

The question of using fireproof material in the construction of ships had reached quite an advanced stage, as had also the use of non-inflammable paints. He felt that the introduction of the modern central heating system was desirable in all ships as it was nearly always available when the vessel was in port. The use of open electric fires and radiators on board ship should be prohibited, in his opinion, as they were a potential source of trouble. In the modern ship the standard of electrical equipment was improving all the time and there was much less likelihood of fires from this source.

One of the reports mentioned the occurrence of a serious fire and explosion through gas escaping via telegraph casing to one of the rooms in the accommodation. The ship referred to was of comparatively recent construction and fitted with MacGregor hatches. She was carrying a cargo of coal from which there was an accumulation of gas which passed up this casing. He agreed entirely that greater attention should be paid to bulkhead fittings for cables, etc., from one compartment to another and this applied to the proper ventilation of holds carrying gaseous or other combustible cargoes.

He thought they were all agreed that to prevent the spreading of fire once it had started should be one of the first acts in tacking an outbreak. Reverting to the fire fighting mediums, he felt that in the future the use of exhaust gases in fires at sea would play a large part as a means of extinguishing fire and the possibility of adapting the necessary producers of inert gases to smaller sized ships by this means would become available when a suitable plant had been designed. The use of CO_2 for extinguishing fires would be the most effective medium probably one could wish for, but the stowage of a sufficient quantity of it to deal with a large outbreak of fire precluded its general use. The use of acid extinguishers was most useful in certain types of fire, especially on the electrical side. The danger to the human element from the accumulation of gas from these extinguishers was always a risk. Steam had been successful in many instances but in the small motor ships of course this was not available. Water played an important part in the fighting of any major fire and there was no doubt that the variable spray nozzle could be most effective.

It was significant that in Mr. Welch's paper he drew attention to the report on the findings of the Committee which investigated the recent disastrous fire in the *Empress of Canada,* that there was very little could be added to the existing regulations except that they should be followed instead of ignored. Surely then the answer to the vexed question of fires in general was not the available fire fighting equipment, which had reached a very high standard, but the educating of the human element to the responsibilities and the necessary training to see that they were capable of understanding and dealing with these emergencies when they arose. This applied to everyone connected with the shipping industry. New fire-resisting materials were constantly being introduced and would continue to be but the failure of the human element to observe simple elementary precautions would defeat all the ingenuity man could devise for his safety.

Mr. G. Bryant, R.C.N.C., remarked in respect of the paper by Mr. Carter and Captain Hogger that the authors of this very comprehensive review of Naval procedure in relation to fire organization had pointed out that the fire hazards in an aircraft carrier were much greater than in any other H.M. ship. He thought it was worth while emphasizing that the fire protection afforded by the high standard of sub-division in H.M. ships was not available in the hangar, which was undoubtedly the most vulnerable part of the carrier from the point of view of fire hazards. It was not difficult to visualize an incident arising in such a vast compartment at the moment when the aircraft lifts were lowered and the ship was under way at high speed. The natural draught would promote the rapid spread of any fire. The adoption of stringent regulations and the use of rapid spraying systems and fire curtains were, therefore, very essential features.

The increasing use of jet fuel as Avgas-driven aircraft were superseded would make a large contribution to the increased safety of operation, but nevertheless the risk would remain fairly high.

Mr. M. Chadwick, O.B.E., commented that practically all outbreaks of fire, as opposed to explosions, commenced in a very small way, and could at some part of their incipient stages be extinguished with comparative ease.

It was a great pity that they could not receive reports of even very small outbreaks of fire, however easily they were dealt with, at the time of their origin, because this would contribute much towards the important phase of the study of causes of fire as against the spread of fire, which of course was studied as a separate subject and which could to some extent be calculated and reduced in many instances. In fact it was quite safe to say that the seriousness of any outbreak of fire was directly proportional to the factors provided either carelessly or accidentally, and which contributed towards its rapid development. Invariably when this stage had been reached the actual cause was difficult to prove, particularly if all of the evidence had been destroyed, and therefore he attached great significance to the fact that a very careful statistical record should be kept if at all possible of all outbreaks of fire, irrespective of whether the consequences were infinitesimally small or otherwise. It was only by a very close study of the causes of fire they could arrive at some definite consequences regarding any particular failure of the human element, and in this connexion he agreed entirely with the statements of the authors as to the proportion of responsibility which could be attributed to this cause.

The reference to the success of loading of petroleum spirit or explosives on board ships by introducing a "No Smoking" order was emphasized in one of the papers, and it was suggested that to some extent similar results could be obtained by prohibition of smoking in other types of cargoes. He did not completely agree with this point of view. He was rather inclined towards the belief that it became a question of personal safety, i.e. the immediate consequential danger to which a careless smoker subjected himself by indulging in this practice under circumstances where he was surrounded by great personal risks, and the fact that he himself might not be able to escape from the immediate consequences. This type of individual became much more careless under circumstances where the immediate danger was not present, and perhaps where the development of the outbreak of fire did not take place until some time afterwards.

On the subject of spontaneous combustion, these types of fires were usually very deep seated and built up a very high internal temperature. On the other hand, a surface fire, not being deep seated, was much more easily approached and tackled on detection, and might be even checked in its incipient stages. With spontaneous combustion the task was much more difficult, extremely long and very laborious.

The suggestion in Mr. Welch's paper that electric drills should be provided to cut an opening about 2 inches in diameter for the insertion of hose nozzles was very sound, and was to be recommended as against the use of burning and cutting apparatus, which could itself produce secondary fires under certain circumstances. He would, however, prefer to recommend that the aperture to be cut should not be circular, but oval, of dimensions of not less than 6 inches × 3½ inches, to facilitate the use of plates by the temporary sealing of the aperture in an emergency; and in this connexion it would be of value if some consideration could be given to the standardization of the plan in order that a number of plates of suitable size could be carried, together with a centre bolt for clamping two of the plates together over the aperture when required. In order to accomplish this, it would be necessary to allow the hand to pass through the aperture to insert the

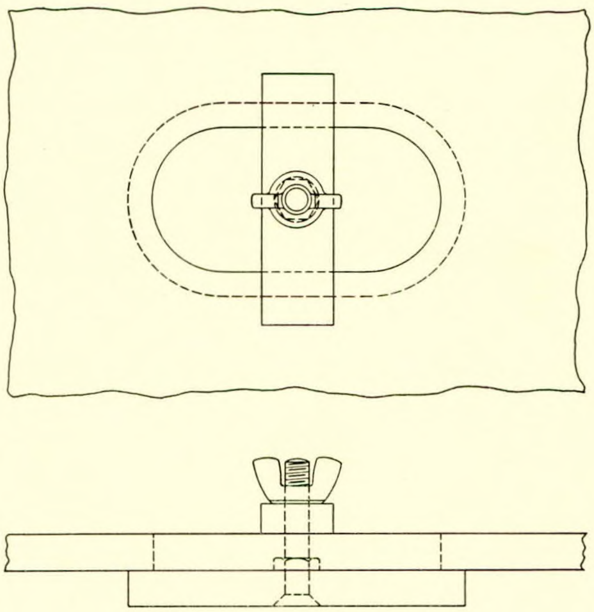

FIG. 4

bolt after the first plate had been passed through, the second plate being clamped over and secured by the use of a wing nut. The cutting of holes in the hull or bulkhead of ships on fire was a subject which demanded a good deal of careful attention and planning, and therefore, if a mistake was unfortunately made, it ought to be possible to rectify the error easily and quickly without any danger of uncontrolled flooding (Fig. 4).

Mr. Welch noted the danger of leaving a cargo cluster switched on whilst resting on inflammable cargo, a very frequent failing, and he would add to this practice the use of temporary repair portable leads with improper joints suspended or even lying on deck and forming part of the electrical lighting circuit.

Several points were made by more than one author regarding the two-gallon fire extinguisher, and in particular reference to the amount of instruction which appeared to be necessary on the extinguisher itself. He had no desire to condemn the two-gallon extinguisher, particularly as he regarded it as being a very fine first-aid medium for extinguishing fire, but he often wondered why more consideration was not given to the installation of non-kink hose reels, with supplies from a header tank replenished automatically from a pressure supply.

Cleanliness in machinery and boiler rooms was the essential factor in the reduction of the rapid spread of fire in such compartments. If this simple technique was very carefully and closely studied, he felt sure that resultant dangers which would otherwise arise would be very considerably reduced.

As regards the use of carbon dioxide (CO_2) as an extinguishing medium, since CO_2 gas was soluble in water, no useful purpose could be served in using these two mediums simultaneously. Steam could be used to preheat the gas before it was ejected into the hold space through the ejection orifices, the reasons for this preheating being obvious. Cold CO_2, being very heavy, would fall immediately to the bottom of the hold, and would take some considerable time to diffuse itself evenly throughout the whole of the air space available. Heated CO_2 would occupy a greater volume than gas at its normal release temperature, and consequently it would expel a greater amount of oxygen from the cargo space in a given time. Furthermore, it would diffuse much more quickly and consequently build up a more uniform concentration of inert gas over the whole of the volume of air space available. This was of significance when one was not in a position to locate the exact part of the hold involved in the fire, especially at sea.

Mr. Welch's suggestion of the tunnel as a means of approach to the lower portions of the engine room during an outbreak of fire was very important. He once made use of the tunnel line as a means of attacking a deep seated fire in the after holds of a vessel by resorting to the drilling of apertures in the tunnel casing immediately adjacent to the hot spots. The insertion of powerful jets into these apertures controlled the fire and contributed much to the general success of the fire fighting operations in this particular instance.

The use of self-contained breathing apparatus to facilitate fire-fighting operations and rescues by the crew of vessels at sea was sometimes jeopardized by the difficulties encountered in maintaining in first class efficient working order apparatus of this nature. He might mention that this was sometimes quite a problem in the Fire Service and entailed a great deal of attention and training, and he was doubtful whether this could be so successfully accomplished at sea where the fire mindedness of the crew could not be reasonably established and maintained at such a high level.

He was of the opinion that more consideration should be given to the permanent installation of ejectors at suitable positions which would allow their use for pumping-out purposes. Indeed, the Fire Service could make use of such ejectors to enable water to be used over and over again for extinguishing purposes, and consequently reduced the danger of overflooding. It would of course be necessary to locate such ejectors suitably and this was a matter which could be studied by naval architects to enable the Fire Services to connect up their high pressure supply to the ejector at some outside point and to use the delivery water from the ejector as a supply for their fire pumps.

Properly installed ejectors could also be used for salvage operations, and he was somewhat surprised that greater use had not been made of these components for this purpose. Properly designed ejectors required no servicing whatsoever, could not deteriorate or become inoperative and they could be located in sections of the holds of vessels without any sacrifice whatever of cargo space.

Very little mention had been made yet of the difficulties associated with the travel of heat through bulkheads, particularly in cargo vessels, thus contributing to the spread of fire from one hold to another.

It should not be difficult to reduce this danger and naval architects should, in his opinion, give some attention to the necessity of having dry drencher pipes above each side of the top of the bulkhead so as to enable a supply of water to be connected up to the system which would spray the bulkhead with a cool supply of water and thus reduce the tendency for the bulkhead to become a very excellent conductor of heat from one hold to another.

He agreed entirely with Colonel Bates's views on the principles of fire organization in ships in port, and would state that his experiences were somewhat similar, especially in connexion with some of the failings associated with patrolling and supervision, etc. One of the problems which he mentioned on page 480 referred to the completely different technique adopted in port to that which pertained at sea, i.e. the nerve centre of the ship, the bridge, being to all intents and purposes evacuated during the time the vessel was in port, and hence warning systems which conveyed their information to this central control station lost their value unless some relay alarm could be fitted to the terminal point, which would serve to raise a warning alarm on entrance to the working alleyway. This appeared to him to be the only way of taking advantage of the expensive and efficient system installed for fire protection purposes whilst the vessel was under commission and at sea.

He agreed with the author's comment on page 481 regarding the expression of the use of two powerful jets. Jets of reasonably high pressure ought not necessarily to be powerful.

In fact two ½-in. jets with a running pressure of about 50lb. would suffice to deal with most outbreaks of fire in their incipient stages, particularly by semi-skilled fire fighters. If larger diameter jets than these were used, for instance 1-in. jets, which could be described as being powerful, a problem arose in the handling of such jets under difficult conditions, and in this connexion he would state that it would need very experienced fire fighting personnel to carry out these duties without exposing themselves to the possibility of unnecessary injury.

Colonel Bates made a point on page 482 of the arrangements made to safeguard a ship in port, and in particular in the selection of the type of individual required to perform fire routine duties.

It was his strong belief that the boarding of ships periodically by fire fighting personnel from fire boats had a much greater value than could at first be realized. The mere fact that these officers and men boarded a ship in order to carry out an inspection was a sufficient reminder to everyone concerned that there was a danger of fire, and served to direct attention to the whole subject; in other words, people on board became fire conscious and a percentage of the alertness inculcated by this practice remained on board the ship. From his experience he would state that the technique was most successful and was likely to pay handsome dividends. It was certainly not time wasted, as was generally supposed in some quarters; of this he was quite satisfied.

He would also like to make an appeal to all concerned to call in the public fire service without delay in all cases, even if the fire had been successfully extinguished before the arrival of the service. The fire services could sometimes find instances when a thorough inspection was certainly justified, and he did not think that sufficient publicity was given to the fact that the services and attendance of the fire brigade were given without any cost whatsoever to individuals either owning the vessel or being responsible for calling the service. The whole of the cost was borne by the tax- and ratepayers of this country, and under these circumstances there was a good deal of justification for calling in the public services in all cases where outbreaks of fire had occurred or where there was any reason to have any doubt whatsoever.

On page 495, the authors mentioned trials of the new P.V.C. or plastic hose. He was of opinion that the advent of this particular commodity must be of considerable interest and value to those concerned with fire fighting arrangements on board ship. One of the big problems associated with the maintenance in first class condition of fire fighting equipment was the effect of weather conditions at sea on fire hose. This plastic hose should be most suitable for this particular purpose as it was quite unaffected by most of the substances which would otherwise considerably weaken the equipment in the course of time.

On page 497, Mr. Clarke and Mr. Hodges referred to the division of passenger ships into main compartments by fire-resisting bulkheads of one-hour resistance. This policy was of great value in fire fighting operations on passenger ships where in the main the bulkheads could be reached during fire fighting operations and cooled down, together with the material undergoing combustion by fire fighting jets. Hence, much was done towards minimizing the rapid spread of fire. However, the problem was somewhat different in cargo-carrying vessels where the bulkhead separating holds could not be reached easily during fire fighting operations and especially at sea, and hence the resistance factor must be made much longer than that specified; he would like to place this problem in the capable hands of the Department of Scientific and Industrial Research, especially as the only contribution he could make towards its solution was the application of water to both sides of the bulkhead by means of dry drencher pipes when the occasion demanded. In this connexion he visualized a problem which must face the master, officers and crew of a cargo vessel on the discovery of fire at sea in one of the holds. If the fire were deep seated or had a firm hold, obviously the policy must be to batten down and make for the nearest port. This would undoubtedly mean in some cases a passage of days during which time the separating bulkheads would get hotter and hotter and considerably increase the danger of the spread of fire to other hold compartments.

On page 499, further reference was made to the improvement of good housekeeping, which of course included cleanliness, previously referred to.

This policy could not be over-emphasized although the difficulties were appreciated, particularly in port during the period when the vessel was either loading or discharging cargo, undergoing repairs or other similar phases, and when numbers of persons not directly connected with the running of the vessel were on board. This, in his opinion, was the danger period, when the ship was in port, and special attention must be paid by personnel engaged on fire patrol duty during these times.

In conclusion, might he introduce a problem which did not appear to have had any previous consideration, but nevertheless was a practice which should be frowned upon. He referred to the use of portable oil heaters in port during the periods that boiler or machinery shut-down took place, and where perhaps there was no other power available for limited heating purposes.

The practice had arisen in the past few years of using portable oil heaters to cover the period of emergency. He would state that if there were no alternative to the adoption of this particular practice, that it was essential to secure the oil heaters so that they could not be knocked over in narrow alleyways.

Near the entrance to cabins or berths portable oil heaters were quite a useful method of providing temporary heating to otherwise cold compartments, but they became a great danger if left standing on their rather flimsy supports on decks without some attempt being made to secure them. In this position they were quite often accidentally knocked over and hence became transformed into flaming torches with running liquid fire spreading in all directions on the deck. More than one serious fire had been attributed to this cause and he thought it was necessary to direct attention to the danger of this practice, particularly on board ship, in the hope that it would remain fixed in the minds of those responsible for such installations, and to emphasize that such types of heaters should always be firmly secured in the interests of safety.

CAPTAIN W. R. COLBECK, R.N.R., had read the symposium papers with great interest. His main interest in fire fighting in his capacity as Marine Surveyor and Water Bailiff to the Port of Liverpool was of course the preservation of the port for shipping. To this end, his department had a close liaison with the fire fighting services in the port. This liaison was particularly fostered in the war years and now it was a common practice for the department to be asked by the local fire chiefs to advise on stability matters in cases of ship fires. In fact, they advised them on the sometimes painful decision as to whether the ship was to be allowed to burn out in order to prevent capsizing and the blocking of a berth. As they knew, this had not always been successful and when working backwards they found how painfully meagre had been the information or even the understanding of the elementary principles of stability. He did not refer to well-found cargo ships that were fully manned and well staffed and where stability information generally was accurate; their construction and cargo made them less liable to capsize. It was the ships under repair mentioned by Colonel Bates that were the real problem in port. Watertight doors were sometimes open, no plans were readily available, a relief officer might be on board and a host of elementary precautions were left uncared for. There was, fortunately, as a result of disaster, a growing realization of these facts, and if plans were left available for the benefit of an authority he felt sure a great stride forward would be made in minimizing the effect of ship fires in port.

In ship fires the responsibility for fighting the fire rested on the senior officer of the fire brigade, but such decisions as to whether the vessel was to be moved to another berth or beached and at what stage the pumping of water into the vessel was to cease to ensure that she did not capsize, remained with the Port Authority.

The technical officer responsible for the provision and assessing of the information necessary to enable these decisions to be made was, in Liverpool, the Marine Surveyor and Water Bailiff. In addition, he had under his direct control two salvage harbour tenders fitted as fire fighting vessels; one or both of these two ships could be directed to a fire by VHF/RT if necessary, to assist in the actual process of fire fighting as requested by the senior fire fighting officer.

The Marine Surveyor himself would establish close liaison with the senior fire fighting officer, and would cause varied information to be obtained, such as:

1. Statistical stability data for the ship.
2. Essential ship knowledge.
3. The draught of the ship.
4. Depth of water under the ship.
5. State of tide.
6. If in dock, whether the dock level of water could be lowered.

All the above items except (1) and (2) could be obtained with precision by people not connected with the ship.

Items (1) and (2) could *only* be provided by personnel directly connected with the ship. True, most items of stability data could be approximated from rough formulæ, but the metacentric height (G.M.) could not and it must be known. What happened, however, when the G.M. was asked for? Replies varied from the blasphemous to the ignorant. On one never-to-be-forgotten occasion the young officer in charge came forth with the reply "The G.M. is x feet and if you put y tons of water in this compartment, the G.M. will be z feet". Afterwards, it was found that the engineer superintendent had given him this information immediately beforehand. But it *was* known.

On another occasion the master of the ship himself did not know the G.M.; his reply was "Oh, she is stiff enough". But was the ship stiff enough to stand the flooding of No. 4 lower hold with the consequent free surface effect? The answer was never known because the fire was extinguished without flooding. Another master—an American—could not be convinced that the value given by filling in a tabulated form did not include the effects of flooding No. 2 lower hold which had a free surface effect of approximately 5 feet. The G.M. must be known and the officer in charge should know it. To this end, it was thought a good idea that the G.M. and essential ship knowledge, such as the state of the fresh water ballast and oil fuel tanks and the condition of any ship's side openings and bulkhead doors should be written down and placed in a sealed envelope and handed over by the officer in charge to his relief. It might very well be a good idea to have an entry made in the ship's log to this effect; after all, most officers were, whilst the ship was loading, required to calculate at the close of work for the day the loading space remaining. How much more important to do a much easier calculation which might prevent the ship from becoming a wreck!

In addition, one should be able to ask for and receive the free surface effects of any main compartment, or at least the value of the moment of inertia for that compartment. It would be a brave man indeed, however, who asked an officer in charge for the appropriate value for the engine room space. The free surface effect of various compartments could be approximated, but how much more valuable and more easily obtained in an emergency they would be if they were in the officer-in-charge's envelope, together with the other information.

Increase of list in a ship on fire almost certainly means loss of stability and one of the first things done on arriving at a ship on fire was to rig up some kind of plumb bob in an accessible position. A scale of degrees was easily calculated by a pocket slide rule, and if the plumb bob was made as long as conveniently possible it was more sensitive than the usual inclinometers found in a ship, and could be sited better.

Thus, armed with the G.M., the free surface effects of various compartments and means to detect an early list, one tried to assess the stability problem with some confidence. Nevertheless, armed with some exactitude so far, there was the factor which was impossible of exact determination, namely, the amount of water pumped into the ship by the fire brigade. If it were confined to a single compartment, a reliable figure could be arrived at, but if, as in a passenger ship, the water was distributed throughout many compartments on several decks, the quantity was impossible of direct evaluation. True, an idea could be obtained from the increase of draught, but any list or excessive trim would cause false values, and in this connexion it was worth noting that a ship with excessive trim could decrease her mean draught obtained in the usual way, whilst still taking in weight. Draught marks should be marked on the ship's side at about the position of the centre of the water plane. True accurate mean draughts would then be obtained.

Now there would be two effects on the stability of the water pumped into the ship. The weight of water would increase the G.M. if it were below the water line and decrease the G.M. if it were above the waterline, and having estimated the weight of water and knowing the original G.M., the new G.M. could be estimated.

The other effect of water, however, the free surface effect, would reduce the G.M. and it was a matter of balanced judgement as to how one effect would balance the other.

If the ship were heeling to an increasing degree with the admission of water, then she was losing stability fairly rapidly, and the water would have to be stopped shortly if the list continued to increase.

However, if the original G.M. were known and the free surface were limited to one or two compartments below the water line of which the free surface were known, then the list the ship would take with maximum free surface and minimum quantity of water could be approximated fairly easily. This condition occurred when the water extended across the compartment from the high bilge to the low side. This was the minimum quantity of water producing the maximum free surface. The list thus calculated was the maximum the ship should take under these conditions, and if the ship would stand this list then as more water was put into the compartment the list would decrease as stability improved, until the level of water inside and out was the same, when the list would increase as stability decreased again. The G.M. with this common water level might very well be greater than the ship's original G.M., but the dangerous condition of minimum weight and maximum free surface must be got over first.

Where a vessel of normal underwater form was lying in a berth with a depth of water below the keel amidships equal to or less than one-ninth of her beam, the risk of capsizing was very remote, as the low bilge would take the ground while the centre of gravity was still on the righting side of the line of contact. In some cases it was possible to lower the level of the water in an enclosed dock to obtain a reduced depth below the keel. Alternatively, if the initial stability were large, it might be possible to produce sufficient bodily sinkage to reduce depth to the desired value by flooding a single watertight compartment if this could be done fairly rapidly.

The question of the state of the ship's fuel, fresh water and ballast tanks, and side openings and bulkhead doors was mentioned as essential items of ship knowledge.

Obviously, double bottom tanks could be used to improve the vessel's stability by filling them, but another and more important point was that an empty or partially empty oil fuel tank under a compartment on fire constituted a serious risk of explosion due to gas. A completely full one was much less risk and any partially empty tanks so situated should be topped up with oil fuel from other tanks, or failing that with water.

The question of side openings was of paramount importance. Obviously, if such an opening were put under water by the ship listing, the danger of capsizing was very great and if a ship listed towards a high quay, it was impossible to see if any side doors were in fact closed or open, hence the importance of the ship's personnel knowing their condition.

MR H. P. GRANLUND, D.S.C. (Associate, I.N.A.) felt he must thank Mr. Welch for his valuable paper, with the wealth of statistics on ship fires which it contained. There were one or two points, however, which were not quite clear to him and on which he would like further information.

The author, on page 472, in his paragraph on accommodation fires in cargo ships, mentioned the use of "flame-resistant materials with permanent finishes". Perhaps he could tell them to what class of materials he was referring. Plastic laminates, which were often used as permanent finishes in the form of veneers, had a comparatively high flame spread and had almost as great a capacity for burning as if they were made of wood. It would be inadvisable to use this type of finish to ensure a minimum risk of the spread of accommodation fires. The author had mentioned that the materials that he had in mind had been used particularly in tanker fleets. Perhaps he was referring to the class of materials known as incombustibles for which there was an international definition referred to in the Ministry of Transport's Passenger Ship Construction Regulations. These were sometimes veneered with plastics in the same manner as plywood.

The tables of statistics were very valuable and showed that fires in accommodation and stores were the second highest category, only being surpassed by those in cargo and cargo spaces. It was surprising to find in the author's concluding paragraphs that only one of his suggested improvements, that of making machinery casings fire resistant, had any real bearing in securing greater safety conditions for the crew and reducing the fire risk in their accommodation and stores.

Perhaps one should look to the Ministry for a greater lead than they had hitherto taken in this matter.

Might he first thank Colonel Bates for presenting such a wealth of information on the fire organization of passenger ships? There must be few companies which surpassed his own in the general awareness of the fire hazard and the good husbandry required both at sea and in port to deal with fires efficiently. This was only one side of the story. The other seemed to be the reduction of the combustible element in the ship to the least-possible proportions. The author touched on this point in the paragraph on materials but did not make it quite clear whether he was in favour of this course of action or not.

The author's statements on the use of light alloys were interesting, particularly when speaking of the peculiar effects of heat conductivity of these metals and their insulation. It was worth considering that if the fire potential of a ship were radically reduced it might be unnecessary, in certain places, to insulate light alloys at all.

A large number of fire tests had already been carried out in this country on aluminium ship structures, possibly more than any other country in the world. They had not yet learnt to interpret these results and, as a nation, lagged behind others in the use of these materials for merchant ships.

It was interesting to see the contrast in viewpoints expressed by the Royal Navy and Merchant Service in the paper by Mr. Carter and Captain Hogger and that written by the previous author. The authors of the third paper stressed the need for the provision of fire restriction barriers in the structural arrangements of the ship and the elimination of as many causes as possible that might lead to fire.

They further emphasized that it was more important that a fire should be contained and extinguished in the space in which it originated. Surely this viewpoint had an equally important application to passenger ships?

Dared one whisper that two of the greatest post-war fires, in the *Empire Windrush* and *Empress of Canada,* could not have happened if greater attention had been paid to this point?

The authors of the fourth paper expounded the merits of the present regulations and the fire tests which were carried out at Boreham Wood to test full scale structures under Standard Fire Curve intensity.

A point which seemed of interest was that under the present fire regulations wood or chip-board bulkheads of sufficient thickness could be made to pass the "B" Class fire tests and their use employed as a fire-retarding division in shipbuilding. Surely the aim should be to reduce the fire capacity of the bulkhead and hence the ship, instead of encouraging the manufacturer to make still thicker and heavier bulkheads which would pass the test and greatly increase the fire hazard of the surrounding structure.

One heard much of the infallibility of the automatic sprinkler installation and of its excellent record at sea. Was there not a danger in placing too much reliance on past history? The authors offered a warning that their function was to prevent the development of incipient fires and they were not intended to cope with those fully developed. Did this mean that the Method II ship was suspect if a large fire developed in the machinery or cargo spaces? There were weaknesses in all three methods of ship construction and this surely pointed to intelligent combination of two or more as giving a satisfactory answer to fire safety in large passenger ships.

One further point, on the dissemination of technical information. Fire tests were carried out at Boreham Wood on payment of a nominal fee by the manufacturers of the product or structure to be tested. It was possible that a small part of the cost of the testing facilities was also borne by public funds. Could not the public have access to test reports of all materials tested at this station (on payment of a fee) instead of their remaining confidential as at present. It was important for the manufacturer of one product to gauge successfully what other product he could use in conjunction with his own without impairing the fire rating or surface spread of flame classification of the whole.

The D.S.I.R. Annual Report remained tight lipped on this question and gave little information which would help. The more information that was known about new structures and materials the more safe and up-to-date would be their ships of tomorrow.

MR. P. G. N. HAYWOOD, having been closely associated with fire fighting in H.M. ships during the ten years succeeding the outbreak of the Second World War, found Mr. Carter's and Captain Hogger's paper of particular interest and hoped he might be forgiven for indulging in retrospect and confining his remarks mainly to that paper.

Mention was made of the inadequacy of fire fighting equipment in H.M. ships at the commencement of the war but it was in fact not until H.M.S. *Sussex* became seriously damaged in an air raid on Glasgow in 1941 that the Admiralty gave serious attention to this important aspect of ship defence.

It was a direct result of this incident that the responsibility for fire fighting in H.M. ships, which had hitherto devolved on a large number of Admiralty departments, was vested solely in the Director of Naval Construction and the Engineer-in-Chief. A policy was then established which, it must be gratifying to the originators to see, had not changed to any appreciable extent.

It was interesting to note that at the beginning of the war there was not a single two-gallon water extinguisher on board H.M. ships; foam type extinguishers (except in aircraft carriers) were confined to boiler rooms and (other than in ships carrying aircraft) there was no main foam equipment. The total fire pump capacity was small and the output of $\frac{3}{4}$-in. jet nozzles large. Considerable effort was necessary to change this situation and it was some time before the whole of the Fleet was equipped and trained to deal with the greatly increased fire hazards involved by modern warfare. Nevertheless, the effect was apparent long before the war ended.

It was a far cry from war hazards to peace time hazards and the fact that there had been no catastrophic fires in British warships since the war should not make them complacent. Every item of new equipment should be judged on the basis, "Would it work when the fire main was damaged and pressure was low?" This applied to the in-line inductor which it was proposed to use on the flight deck. Equipment should also be simple to operate, have the minimum of working parts and therefore be easy to maintain.

A watchful eye was also necessary on the tendency to increase the amount of combustible material on board as a result of the recent efforts to improve habitability. Whilst the writer was inclined to agree with the remark of Lieutenant Colonel Bates in his paper that "there is need for a sense of proportion in this matter", wood when fireproofed generated much smoke if involved in a fire, in addition to which experience had shown that owing to its not being readily apparent whether timber was fireproofed or not, unproofed timber found its way into ships despite constant vigilance.

CDR. G. M. D. HUTCHESON, R.N.(ret.) (Associate, I.N.A.) thought that the valuable tables supplied by Mr. Welch brought out a triple emphasis: the risk of complete total loss and casualties from unknown causes; the high incidence of fires in accommodation (90 per cent of the total for cargo); and the menace of careless smoking. The aggregate of "unknown" plus "smoking" in Table II was too high to permit a belief that the preventive or remedial measures surveyed in the paper were the optimum.

If out of 212 causes of fire in accommodation the nature of thirty was not known, and if it were known that smoking contributed another seventy-one, it might be thought that these 101 causes out of 212 were worth some special attention. But a significant omission from the author's list of fire precautions was the construction of accommodation in non-combustible materials which gave a general protection against both "the unknown" and the uncontrollable, the latter exemplified by smoking, sabotage and collision.

Would Mr. Welch explain what he meant by "flame-resistant materials and finishes which did not need painting"? Had his term "flame resistant" any formal or accepted definition in the 1948 Convention Rules, in the 1952 Construction Rules, or in British Standard Specifications? Was "flame resistance" not a claim which could be loosely associated with any material without it having to be submitted to test? Would he confirm that "flame-resistant" materials, or those with low flame spread (to quote him), "ensure a minimum risk of accommodation fires"? If the materials burnt—as do many, perhaps most, low flame spread materials—how could it provide *minimum* fire risk when others of negative flame spread and nil combustibility were available?

The author, perhaps concentrating professionally, deplored complacency in regard to the fire risk in machinery spaces. His table showed a higher incidence of fire causes in accommodation and stores (the figure was 212 as against 165 for machinery spaces). Was not complacency equally misplaced about accommodation structures, especially in ships like tankers and freighters for which no regulation or apparent concern existed? "Flame-resistant" materials did not seem to be a very promising or well defined field of recommendation to the fire-conscious owner.

The tables referred to British casualties only and so there was no mention of two major fires round their coasts during recent months. Both fires were in Scandinavian tankers at different times and places, and followed the holing of each tanker by colliding vessels; both fires extended to accommodations aft and amidships. In one, loss of life was very heavy; in the other it was fortunately light, though non-lethal casualties were high. In neither case would it appear possible to allocate blame in the holed ship. It was suggested that collision was a fairly common marine accident and a very real starter of fires, especially in tankers, and was no respecter of nationalities.

Mr. Welch suggested that recommendations of a moral and cautionary nature had been disregarded and nearly every contributor to the symposium referred to human fallibility and to the unpredictable hazard of fire. The best way to combat laxity, human frailty and surprise was to deprive them in advance of their effects by building into the ship every proved precaution which could be afforded and which did not interfere with her basic design and earning capacity. Norwegian Veritas was understood to be considering a scheme whereby such a ship received an official fire rating; this might affect insurance rates to the advantage of the owner and in general it encouraged the establishment of a category of fire-safe ships.

To a student of merchant ship fire protection, Colonel Bates's very generous paper was of the greatest value since it represented the views (technically yet understandably phrased) of a practical ship operator of vast and varied experience. Some questions were, however, put with respect.

First, did Colonel Bates mean that attempting the target of ultimate fireproofness involved undesirable overemphasis on the unattainable, or did he mean that to publicize that a certain ship was fireproof tended to relax the crew's and passengers' awareness of the danger? Did he, in fact, dislike the ambition or just the propaganda? In this connexion, was Colonel Bates prepared to accept the definition of an incombustible material as one which "when heated to a temperature of 1,382 deg. F. neither burns nor gives off inflammable vapours in sufficient quantity to ignite at a pilot-flame"?

Reading between the lines of Colonel Bates's remarks on wood in accommodation, one suspected that he held a view that there was indeed some satisfactory half-way house between woodwork and the metal box technique. One presumed and hoped that he would not object to find wood as a surface finish applied to an unseen non-combustible (by definition) core material, and that such a combination would satisfy him æsthetically and add nothing to the fire hazard.

Colonel Bates's statement that a failing of both sprinklers and smoke detectors was that a sizeable fire could exist before they functioned surely pointed to the incomplete nature of a fire plan which depended, as to 100 per cent, on the existence of a sprinkler system (as did Method II). An improvement by a dovetailing with Method I was obvious and practical. This would seem to be underwritten by the author's remarks that "the ship. . . . .is wholly designed, built, maintained and operated to offer the greatest resistance, consistent with her function, to the hazards of the oceans, including fire when at sea". The ship with a known built-in weakness could hardly fulfil this eclectic specification.

With regard to the statement that with rigid asbestos boards it was difficult to provide adequate insulation on one side of a bulkhead if the boards were fixed directly to it, would not Messrs. Clarke and Hodges agree that at least one such board and its simple erection system have been fully tested and have fulfilled the requirements of the Ministry of Transport as to both integrity and heat transmission?

The authors were to be congratulated for restating the axiom that if the fire load were reduced, there was less to burn and the structure was that much safer. This seemed to be a desirable and perfectly achievable aim. It had in fact been done in hundreds of ships.

MR. W. B. JOHNSTONE, O.B.E. (Member) wished, before making any observations on these papers on fires in ships, so ably dealt with by their learned friends, to make it perfectly clear that he was speaking as an individual and not for the ship repairing industry.

The authors of these papers had to be congratulated on their general outlook on fires on board ship and the amount of trouble they had taken in assimilating the many causes, both in ships at sea and in port. Indeed, the papers had been most informative and would give many who handled these problems quite a bit to think about.

Having witnessed two fires, one on a refrigerated merchant ship and the other on a naval cruiser, he was more convinced than ever that the human element must be trusted to a much greater extent than any mechanized device in the detection of fire.

On pages 472, 480, 481 and 499, the authors stressed the use of the sense of smell in the detection of fires. There were other faculties such as alertness and conscientiousness which played an equally important part in fire watching on board ship. All these senses could be developed in the human race by good leadership, despite the human frailty. At sea every person on board ship had an interest in preventing, detecting and extinguishing fires, as his own life and property might be involved. In port the job took on a different complexity as the fire patrol then had only the job to do on a particular ship which might not last for any great length of time. This gave the firewatcher an entirely different outlook as it was not his home nor did he lose any personal property. Some other motive had therefore to be installed in his mind and this his company tried to do by having the best relationship possible between their firewatchers and management.

These firewatchers were under one foreman whose task it was to make sure that all burners, welders, etc., had a fireman with them to watch the opposite sides of the bulkheads they were working on and, at the same time, these men, under the same foreman, were charged with the task of looking after the scrap and keeping a lookout for any vandalism or theft which might be taking place on the ship. This foreman's duty was to get his team to know the various ships, the officers and the various hydrants and fighting equipment and make it thoroughly known to the men so that they could lay their hands on any equipment necessary within the shortest space of time.

They were very insistent on the patrol for the first two hours after the men stopped, as through many talks with the firemasters in the district they had learned that it took a cigarette end approximately two hours to set fire to a cushion after a tired father had let it slip through his fingers before retiring for the night and before the smell wakened the household to alert the fire brigade.

Many of the larger passenger liners were fitted with sprinklers. This was a most useful fitting on any ship but despite this they had an understanding with the fire brigade when these larger liners were with them by which a fire alarm was fitted at the foot of the gangway and at frequent intervals the firemaster came with his fire engine and organized a fire drill. This was very useful as it allowed the fire brigade to learn the quickest way through the yard and when they reached the ship and found out where the fire was they had to run their hoses, which gave them a knowledge of the ship.

In all cases a hose was fitted from the hydrant on the shore to the ship's fire main and this was useful for other things as well as fire fighting. At this point let him say that the British Standards committee might at least discard two of the three standard fittings used for hoses and have one common hose coupling for all purposes.

He thought that it was advisable to allow men to smoke on board ship but to point out to those who were working near inflammable material that it was in their interest and the firm's interest to refrain from smoking in case they caused a fire but to go to a prescribed area on the ship in which smoking was allowed. By doing this they overcame the difficulty by which men nipped cigarettes when approached but did not ensure that the nipped cigarette was exterminated.

Another dangerous practice which occurred when ships were in port was the home made electric heater rigged primarily for the boiling of cans for making tea; these were always of the open-element type, were tapped into any nearby electric supply and very often during working hours these were knocked over and caused endless destruction and trouble, always resulting in a fire of some sort.

There was just one word of warning about the use of hydrants round the quay walls throughout the harbours in this country. It was surprising how much the town pressure fell and it was very important for users to make sure that there was sufficient pressure of water.

It was known that they had to compete in this world for survival and before allowing the idea of fires in ships to spread among the backroom boys he would appeal to them all to examine the human relationship between their men and the job they did before getting involved in grandiose schemes produced by people who had no conscience regarding cost or the practicability of working a job.

Think of the many tedious hours a man must spend walking around a ship during the night and unless this man received some encouragement from those to whom he was responsible he would very quickly become discouraged. They were living in queer times just now in which many men only lived and worked for their own self-glorification and played the game only to the letter of the law. It seemed to him that as each year passed the older technique of playing the game and enjoying it and responding to the spirit in which the rules were written had gone and this meant that nobody must be found with the can or the ball in his possession; it must be passed on to somebody who was going to have to take the rap and what they found to be happening was that when a ship was being repaired, in many cases about four or five different people had insured the ship for exactly the same risk. What a Klondyke for the insurance brokers!

Capt. R. R. Kippen, C.B.E., wrote that his experience had shown the need for a reserve water tank capable of being coupled up to the sprinkler fire pump when the ship was in drydock and even in the wet dock, where the water was often contaminated and a possibility of the pump suction being in the mud in shallow berths. All ships' sprinkler systems had deck connexions for coupling up to the shore mains but since the authorities would not allow these connexions to be coupled to the suction side of the ship's sprinkler pump, presumably because there would be a danger of the shore mains being flattened, these connexions were made at a predetermined point on the discharge side of the sprinkler main pipe. In the result, this meant that the shore pressure seldom exceeded 30lb. per sq. in., even less if the shore mains were connected to other ships in the vicinity, and this pressure was quite incapable of operating the sprinklers once the head in the pressure tank dropped.

In view of this it was his company's practice to keep 100 tons of fresh water in a double bottom or peak tank coupled up to the suction side of the sprinkler fire pump. They believed that this arrangement would keep the sprinklers in operation for a sufficient time to either douse the fire or give adequate warning to the ship's central fire station.

It should be noted that certain drydocks might be able to supply water under sufficient pressure to maintain the sprinklers independent of the pump itself, but they were the exception rather than the rule.

One other point which was of some importance in regard to this system was the fact that in severe winter conditions where the temperature had dropped well below freezing point, there was danger of the silica bulbs being detached from the metal parts of the sprinkler head because of the difference in the coefficient of expansion in the two materials. It would at the design stage, therefore, seem desirable to give some consideration to the desirability of placing the sprinkler pipes in the proximity of the air conditioning trunking and to maintain this in operation during the period of severe weather, even although the section might not be in use. This, of course, referred to a passenger ship where the sprinkler system was divided into sections throughout the whole accommodation.

In considering Mr. Welch's paper, he definitely disagreed with his contention on page 472 that the first rule in such fires was to use the nearest appliance. Should the fire be in the electrical installation it might be extremely dangerous to use a two-gallon soda acid extinguisher, which might be the nearest appliance. In his opinion, the best method of dealing with a small electric fire in an electric fuse box locker or the like, was a combination of the dry powder pistol followed by a charge of CO_2 from a small cylinder extinguisher fitted with a spreader nozzle. Usually the powder pistol blanketed the fire but due to the possibility of the current being still in circuit and the wires very hot in the very early stages they had found it desirable to douse the fuse box with a charge of CO_2 which acted as a refrigerant and prevented re-ignition.

In modern passenger accommodation where the distribution of the electrical supply was through a system of electrical lockers placed at various points throughout the accommodation, he was of the opinion that these lockers should be equipped with a powder pistol and small CO_2 extinguishers.

With regard to the differences of opinion on the question of water pressures on board generally, he was of the opinion that a pressure of 80lb. per sq. in. should be available at the upper, or promenade deck, level for three important reasons:—

(1) In modern ships, especially motor ships, he had found that a foam branch pipe as described in the Naval procedure paper was of the greatest advantage as it would at 80lb. pressure throw a 55ft. jet of foam mixture of great tenacity which might prove invaluable where the seat of the fire could not be approached.

(2) In the defence technique for a ship in the vicinity of a nuclear explosion, a continuous water spray over the whole of the top hamper of the ship minimized contamination. He estimated that 80lb. pressure was necessary to do this.

(3) In the event of a major conflagration where a ship might take a heavy list due to trapped water in accommodation resulting in the desirability of using a portable ejector pump from the ship's fire mains, a pressure of at least 80lb. would be required for efficient operation. He was here thinking of this happening either at sea or at a small, poorly equipped port abroad.

He quite agreed with Mr. Welch that the matter of breathing apparatus was a controversial subject but it was his considered opinion that the self-contained compressed air breathing apparatus had made considerable progress in recent years and was to be preferred to the air bellows or blower type. He was also of the opinion that some experiments with sound-powered batteryless two-way telephones should be considered, possibly as a part of the breathing apparatus.

Notwithstanding human frailties, he considered an efficient fire patrol to be still the best means to avoid a major conflagration either at sea or in port. It should be appreciated, however, that this was a soul-destroying job and every effort should be made to ring the changes so that the personnel employed on this work were given a break from the monotonous round. This was a matter which must be left to the ingenuity of master and chief officer but it would call for a high degree of enthusiasm and zeal on their part. Colonel Bates had rightly emphasized the value of the human nose, which no automatic warning device could emulate.

In passenger ships in port, he was of the opinion that a book should be maintained at the gangway or central fire station showing the distribution of weights throughout the ship, tanks and contents, with or without free surfaces, and any other relevant data such as hazardous cargo stowage, draught and corrected G.M., kept up-to-date daily. This book should also contain an up-to-date capacity and general arrangement plan for ready reference. In his own company this had been the custom for several years and had become routine practice.

DR. C. D. LAWRENCE, B.Sc., considered that in the paper by Mr. Carter and Captain Hogger the authors rightly stressed the serious fire risk due to interior paints in warships which was incurred in the past prior to the introduction of the special fire-retardant paints now in use. The conventional types of oil or synthetic resin-based paints were readily inflammable and rapidly propagated fire from compartment to compartment.

The ideal fire-retardant paint was one that was entirely incombustible and hence solely inorganic in composition. It was possible to formulate such a paint but it had serious disadvantages in other respects. In particular it possessed no elasticity and would crack under the movement of the warship at sea, thus giving rise to corrosion troubles. It was necessary therefore to incorporate a proportion of organic medium in a fire-retardant paint. The amount of this organic medium present had to be carefully balanced; in order to give good fire retardance it was kept as low as possible but it had to be sufficient to impart elasticity and adhesive properties to the paint. From a habitability standpoint it was important too that the paint film, which was light in colour, should not be readily soiled and should be capable of standing periodical washing with soap or detergent solution. These requirements tended to increase the proportion of organic medium so as to give a semi-gloss paint. The composition of the pigment in the paint had to be carefully controlled so as to give optimum fire-resisting and anti-corrosive properties.

In formulating the existing fire-retardant paint to Defence Specification 1114, all these and other matters had to be considered. An important advantage of this paint, which was based on a gum dammar medium, was that on heating it adhered tenaciously to the bulkhead and did not form large blisters. Conventional paints generally blistered on heating and the burning film became detached, frequently forming a shower of glowing fragments which rapidly propagated the fire.

Research was proceeding with a view to effecting still further improvements in the fire-retarding properties of the existing paint without affecting its other properties, by the incorporation of special inhibitors such as zinc borate. The use of chloro-type media and plasticizers was also being explored although these had certain drawbacks which had to be overcome before they could be generally adopted for Service use. It was apparent that any further advance that could be effected in this field would have considerable importance in still further reducing the fire hazard on H.M. ships.

REAR-ADMIRAL A. L. P. MARK-WARDLAW (ret.) (Member, I.Mar.E. and I.N.A.) had been greatly impressed by the papers wherein the authors had given a profound and effective account of, in the main, the methods of dealing with fires.

In an age where more and more sea traffic was done in chemicals, in atomically related substances, and in goods manufactured from such substances as unstable polyesters (it had been reported recently that two ships' fires were caused by cups and saucers of this substance disintegrating), it would seem essential not only to be adequately equipped to deal with outbreaks of fire, but also to ensure that cargoes which might be hazardous should be packed and stowed under the direction of experts, whereby risks and possibly even chain reactions were avoided.

He would like, therefore, to draw attention to some of the many contributions now being made with the object of *avoiding the occurrence* of fires in ships, the following three being, broadly, the main examples:—

(1) Proposals for the standardization, packaging and marking of dangerous cargoes, now being studied by a United Nations Committee.

(2) The International Container Bureau were making a study of the conditions with which containers should comply in order to be suitable for carrying dangerous goods.

(3) The widely growing attention and support which was being given to the work of such bodies as the National Cargo Bureau in the U.S.A. in respect of the certification of correct stowage of cargoes, amongst which were included so-called "hazardous goods".

MR. H. S. PENGELLY, C.B. (Member of Council, I.N.A.) had the experience during the late war of serving in an aircraft carrier when fire broke out in the hangar. The fire started by spontaneous ignition in some netting stored under the roof of the hangar; the netting was not part of the ship's normal equipment but was being carried to the Eastern Fleet in the ship for want of other store carrier space.

The fire was discovered at a very early stage and might well have been put out without difficulty if the man on the spot had known how to use any of the many fire fighting appliances available. In the event, the middle section of the hangar between two safety screens was more or less burnt out and the fire was not brought under control before the ship carried a few hundred tons of loose water with considerable free surface, many feet above the waterline—not a happy state of affairs at sea in war.

This experience underlined the importance of the following:—

(1) Fire fighting equipment must be carefully examined at frequent intervals to ensure that it is in an efficient condition. There were hoses with holes in their sides which practically destroyed their effectiveness.

(2) Every effort must be made to get rid of water used in fighting a fire. In this case the ship was carrying additional stores on the hangar deck; these impeded the flow of water to the drains, some of which became choked.

(3) And most important: all personnel should have some training in fire fighting; it was not sufficient to carry out a routine weekly fire drill. That the importance of training was now well appreciated by the Royal Navy was clear from the paper by Mr. Carter and Captain Hogger. Could the same be said of the Merchant Navy? The best fire fighting equipment would be of no avail if the men concerned were not familiar with its use and trained to use it with confidence.

MR. R. F. SERBUTT, S.B. (Associate Member, I.N.A.) considered it to be inevitable that the defence of a passenger ship against fire be dealt with as a defence in depth, for he did not think that, in normal circumstances, one line of defence could be made impregnable. It might be worth while to set the problem up qualitatively in order to emphasize these successive lines.

The first line of defence was adequate subdivision of the ship by means of bulkheads able to contain a fire for some considerable time. The statutory bulkheads spaced 131 feet apart, combined with decks made effective by enclosure of lift wells and stairways, provided between them quite an effective measure of compartmentation. Except in sprinklered ships, additional bulkheads would be fitted, even to the ultimate extent of having all cabin bulkheads of incombustible material.

Secondly, there was the control that could be exercised over the amount and nature of combustible material in each compartment. Little could be done about oil fuel, personal effects, mails, cargo, and a lot of odd pieces such as the butcher's block. In regard to furniture and fittings, however, there had to be considered, firstly, the calorific value, and then the nature of combustion. Material which ignited easily and then gave off a lot of heat combined with dense black smoke was not very suitable from the point of view of fire protection. If cabin bulkheads were of incombustible material, there was the double advantage that not only was the subdivision improved, but at the same time, the amount of combustible material was reduced. Whatever else might be done, the so-called "good housekeeping" was an excellent way of removing what would otherwise be fuel for the fire.

If a fire did have to be extinguished, the simplest and most reliable way of doing that was by means of some automatic warning and extinguishing system, generally those in British ships consisting of sprinklers for accommodation spaces, and smoke detectors combined with carbon-dioxide flooding for the holds. About the only remark that could be made in regard to automatic systems was that such attention as they needed should be provided for in some sort of schedule which should be scrupulously adhered to.

The last line of defence was the ship's fire party. In addition to having proper equipment and an adequate supply of fire extinguishing media, they would need to have had some training in fire fighting. It was important that fire fighting operations should commence while the fire was still in its incipient stages, and that meant getting early warning and then going into action quickly. Not all ships would be subject to a major conflagration, but in those that were it should be too much to expect a ship's fire party to handle the matter to any greater extent than by keeping it under control while the ship was being abandoned. What he thought would be of benefit was a fire fighting plan worked out in a fair amount of detail for a particular ship. It would be much easier to modify such a plan as circumstances might require, than to have to devise an entirely new one at the time of a fire.

MR. R. K. WOOD averred that over the last twenty years, since sprinklers were first adopted in Britain as the main line of defence against fires in passenger ships' living spaces, confidence in the system had never wavered and the evidence given in the papers supported this confidence. The sprinklered spaces appeared to be in good hands even when constructional material was combustible, so long as the system was allowed to work. Nevertheless, there was still need for an efficient patrol system, especially since certain spaces containing electrical equipment—auxiliary switchboard rooms, vent unit rooms—were not normally fitted with sprinkler heads. The figures quoted on page 500 showed that over a period of nine years thirty-six fire incidents out of a total of forty-three were detected by the watchfulness of patrols of ships' staff.

A machinery space fire, resulting in the sprinkler pump being put out of action, could endanger the whole ship. For this reason some owners had already adopted a duplicated sprinkler pump independent of the ship's main electrical system. If greater security were desired beyond that provided for living spaces by existing rules, this was the line to be followed.

Two minor points were worthy of mention.

Colonel Bates implied that an aluminium alloy boundary uninsulated might conduct heat away as fast as it was generated by a fire and remain intact. If the standard fire test were any guide, the temperature of the boundary would quickly rise to the stage of instability and collapse. The sprinkler head near the seat of the fire was there to reduce the rate of heat generation and so control the temperature rise in the alloy boundary.

More than once in the papers the value of a keen sense of smell on the part of ships' officers and patrols was mentioned. Would the absence of this sense, which was not uncommon, be considered, like a deficiency in colour vision, as a disqualification?

Authors' Replies

Reply to the Discussion on "Survey of the Causes and Methods of Extinction of Fires in Ships"

In answer to Mr. MacTier's most useful contribution on engine room fires, with which Mr. Welch agreed wholeheartedly, there was one point on which a word of warning appeared desirable. While the removal of smoke was an accepted procedure in shore fires, it seemed unwise to risk creating a strong through-draught by opening skylights unless all bottom openings were shut and this use of the skylights, he suggested, should be restricted to cases where a quick-closing airtight door was available in the tunnel as Mr. MacTier suggested. His reference to the remote control of dumping valves for running oil from service tanks to the double bottom was noted with interest as also was the reference to boiler ignition units which were now standard practice in shore power stations.

On the question of the exchange of information about ship fires between owners, the author was thoroughly in agreement. As already mentioned, the Ministry had considerable information on this subject as a result of casualty inquiries and he had suggested that the lessons learned should be published for the benefit of the industry as a whole. The Ministry was now working on this proposal.

Both Mr. Hayward's and Mr. Wray's suggested use of the $\frac{3}{4}$-in. unkinkable hose was no doubt a desirable addition in spaces not protected by automatic sprinklers, although it would only come into use where the available two-gallon extinguishers proved inadequate, by which time the standard size hose would probably be called upon. Mr. Wray's remarks regarding toxic effects from carbon tetrachloride extinguishers were also noted and any such extinguishers allowed for special restricted use in ships carried the printed warning. His suggestion that recharging facilities should be provided for the cylinders of compressed air breathing apparatus was not readily applicable to ships since their air supply was normally of much too low a pressure and a special high pressure compressor would be necessary on each ship. The scale of spare cylinders recommended was based on the assumption that recharging could not be carried out on board.

In answer to Commander Walmsley's enquiry regarding the automatic fire valve referred to in B.S. 799, the Ministry's oil fuel requirements for ships called for a foolproof burner valve but while a boiler attendant was always on watch the need for an automatic flame failure shut-off valve was less necessary. It had been fitted in some cases, however, where the boiler was liable to be left unattended. The author suggested that the most dangerous fire risk occurred when a burner dripped oil without the flame going out, which eventuality did not seem to be covered by the automatic fire valve referred to.

Mr. Firth pointed out further advantages of the fixed water spray installation and in answer to his query it was confirmed that the reference to the "attractive variation" was as an addition and not as an alternative to any statutory requirements.

The author thanked Mr. Bedford for his complimentary remarks and also for drawing attention to the limiting temperature at which the isotope level indicator for CO_2 bottles became ineffective. This should not be a serious disadvantage in temperate climates and might even encourage owners to install their CO_2 bottles in a reasonably cool place.

Mr. Smith's reference to "failure of present equipment without exception" was rather startling as the author had records of several cases of complete extinction and it might well be that the type of cargo and the trade in which such sorry experience was gained had some bearing on the matter.

In reply to Mr. Greenslade, the author agreed that no amount of sifting of evidence as to the cause of fires would reduce their number but such sifting was useful if it pointed the way in which preventive efforts could be best directed. Regarding electrical fire risks from temporary wiring in port, this matter was covered at some length in paragraph 20 of the 1950 Working Party Report on Fire Prevention in Ships in Port and indeed there was a strong case for this publication to be given continued publicity. Since its first publication about 10,000 copies of this report had been distributed and the *Empress of Canada* fire gave it considerable publicity. It might be mentioned that the report was also reprinted in full in the Ministry's Fire Appliances Rules, of which some 6,000 copies had been distributed.

With regard to the drainage of accumulated water from 'tween decks and passenger spaces, the author was satisfied that several methods were indeed available but with the sprinkler protected ship it would be difficult to insist on elaborate arrangements which in any case would be more likely to become of major importance in an uncontrolled fire in port where shore assistance was usually available and where it was hoped that the provision of appliances capable of supplying such a quantity of water as to endanger stability would include means for getting rid of it.

Captain Shelford seemed to imply that the author's opening remark about breathing apparatus doubted its usefulness. Such was very far from being the case and very many instances could be quoted of fires in merchant ships where the apparatus had done excellent work. There were records of only one fatality at sea with any type of breathing apparatus during the last ten years, this case having been due to gross lack of maintenance.

Mr. Strother-Smith would appreciate that the author had of necessity to be circumspect in claiming overall superiority for a particular method of extinction and indeed with so many variables such as type and quantity of combustible material it would be most difficult to do so. He would, however, go so far as to say that a study of the actual reports showed clearly that the training of the crew was of paramount importance in a machinery space fire, that a slightly less expert degree of training was necessary in accommodation fires, especially where sprinklers were fitted, and that hold fires were usually the least rapid and, the spaces being already closed down at sea except for ventilation, rendered fire fighting rather less a matter of seconds. A seaman's common sense would usually dictate suitable action in hold and accommodation, whereas the ramification of connexions in a modern machinery space called for specialized knowledge. On balance the short answer was that training of crew was of greater importance than the effectiveness of the system.

Mr. Strother-Smith would see from other speakers in the discussion that the use of inert gas generation for oil fires was receiving attention.

Finally, Mr. Strother-Smith voiced very strongly an opinion held by a great many speakers at this symposium, namely, that extinguishers should be standardized in their method of operation to a far greater extent than they were today and that the contents and instructions should be much more clearly displayed. If the majority of shipowners and superintendents could agree on a standard method of operation there was no doubt that the suppliers would gladly supply them. On the question of instructions, however, the author considered this was an immediate need for the very reason that methods of operation of existing extinguishers varied so widely and he saw no justification at all for the name of the apparatus or its suppliers being allowed to detract from the clarity of the instructions. He could name a great many appliances for other purposes whereon the maker's or supplier's name appeared only in the smallest print and he believed the time was ripe for making this a rule for the two-gallon fire extinguisher.

Mr. Sohoni raised doubts as to the efficiency and reliability of the inert gas generator for cargo holds. The author suggested that in regard to the time element, statistics of innumerable cargo fires showed that the half-hour quoted was sufficiently rapid for all dry cargoes other than chemicals. Reliability was another matter but there was a limit to duplication of emergency appliances and this particular apparatus could be tested at full discharge rate as often as desired. It was rare for hold fires to assume serious proportions without ample warning.

The author was in agreement with the remarks on light coloured paint as an aid to cleanliness and had some further remarks elsewhere in his replies on the subject of fire-resistant paints. He also agreed that extinguishers should be in prominent positions but in any case their whereabouts should be familiar to a trained crew, while drills on No. 2 hatch did not comply with the published instructions on the matter. Perhaps the smoke bomb might serve to give realism to a fire drill.

Mr. Mear raised a very pertinent question in regard to the absence of any mention of oil tankers in the paper. This was deliberate for several reasons, as follows. The paper as written had already exceeded the intended length, the subject was a large one when it included, as it must, explosions in cargo tanks, the few fires in records had in most cases been the aftermath of serious explosions and the causes of these explosions were still somewhat obscure, with opinion veering towards the static electrical rather than the mechanical friction spark when more obvious causes were not present. The fact that tankers in peace time had in the past enjoyed a large measure of immunity from fire, especially when at sea, was reflected in the absence of any special equipment in statutory rules other than steam or gas smothering to render the ullage space safe in the event of fire elsewhere. Inert gas could of course be used for this purpose and the method described by Mr. Mear for inerting a tank during cargo discharge operations was understood to have been practised to a limited extent in the U.S.A. The subject was one which might commend itself to the tanker companies.

Regarding the provision of a portable inert gas generator as part of a port's fire fighting equipment, no doubt several of the Fire Officers present would be giving this matter some thought, reduced cargo damage and the absence of the capsizing risk being attractive features. On the question of rate of application in a hold fire it had to be remembered that destruction of cargo and structural damage were liable to be heavy if the rate of injection were unduly reduced.

Lt.-Cdr. Ranken touched on a very large number of points with which the author was in general agreement. On the question of sand, the Ministry regulations recognized its usefulness and called for sand or other dry material. The rigorous objection to sand, mentioned by Lt.-Cdr. Ranken, could not be very insistent since the author had never seen any owner availing himself of the alternative. Regarding the inclusion of questions on fire fighting in the Merchant Navy engineer and deck officers' examinations, this had been done for several years.

Mr. Wilson made a useful suggestion that CO_2 gas used for fire smothering should incorporate a stenching agent so that on re-entering a space where CO_2 had been used the fire fighters would be aware of its presence. A candle or hurricane lamp would of course serve the purpose where it was safe to use a naked flame and fortunately anyone temporarily suffocated by CO_2 suffered no ill effects; nevertheless, it would be useful to be able to smell this invisible gas.

Mr. Arrowsmith dealt at some length with smouldering fires in ships using cork insulation for refrigerated cargo holds and in reply the author confirmed that while no such fire had been reported at sea in the period under review, such fires had occurred quite frequently in port, particularly from welding. The substitution of non-inflammable insulation such as glass wool for cork, at least on bulkheads to prevent fire spreading from one space to another, was good insurance. During fire fighting operations, chasing the hot spot by water from a hose through holes cut in the upper part of the sheathing had proved difficult. The author considered that with gastight closure of the space an ample supply of smothering gas would be bound to reduce the smouldering, since, even if gas could not penetrate the sheathing, the cork would only have a limited amount of oxygen within the sheathing. Another aspect of the matter would be the class of cargo, since, if it were to be ruined by smoke anyway, flooding could cause no greater loss and would certainly be effective. For the actual flooding it might be necessary to have bulkhead non-return bilge valves capable of being lifted by extended spindles, as was the practice with some companies. No doubt Mr. Arrowsmith would have noted Mr. Chadwick's drencher pipes for bulkheads.

Regarding fire-retardant paints, Mr. Carter and Dr. Lawrence had each provided information on such paint used in warships. The author's personal knowledge of fire-retardant paint was limited to the white lead and paraffin mixture used on steam pipe lagging and he suggested the best approach would be to ask the manufacturers to supply a fire-retardant semi-gloss paint for general use in machinery spaces and try it out in service. A completely non-inflammable gloss paint was not at present available and a compromise had to be accepted. The author was now a firm believer in what was commonly known as aluminium paint. From a fire-retardant point of view it was, he considered, definitely better than the usual metallic oxide-base paints in that good coverage could be obtained with a very much thinner coat and a dangerous build-up by successive coats was less likely.

Regarding oil or dust behind cable trays, the author knew of no cure for this common fire hazard except that where a choice existed the tray might be placed vertically with advantage. He fully agreed with Mr. Arrowsmith's suggested placing of a fire hydrant near the access door. The warning regarding water on electric machines was timely and in this connexion spray was less dangerous both to the fire fighter and the machine.

The author thanked Mr. Barber for the useful additional information regarding CO_2 smothering for machinery spaces, crankcase smoke detectors and CO_2 liquid level probe and for the warning that some cut price CO_2 installations might not be giving the owners the degree of protection they expected.

Mr. Beattie provided much information that served to emphasize various points made in the paper. In regard to danger from electric radiators the Ministry's recently published Instructions regarding the Survey of Passenger Ships contained restrictions on the type used in accommodation designed to reduce the fire hazard. The author queried "the use of acid extinguishers especially on the electrical side". Regarding ventilator closing the author hoped Mr. Beattie would be successful in getting the improved types referred to on the market.

The author had for long suspected and was now convinced that Mr. Chadwick had a hobby which was fire fighting in ships and his valuable contribution was very welcome. He could be assured that the study of small fires was diligently pursued by the author and his staff, who had the advantage of statutory authority in the matter. The author agreed with the suggestions regarding openings for hose nozzles and had taken note of the size of opening in the model shown at the lecture. The danger of temporary electric leads was referred to in the author's reply to Mr. Greenslade.

With regard to non-kink hose reels, usually of small bore, ¾ inch had been mentioned; the author was satisfied that they would be useful equipment but hesitated to suggest that they be made an additional statutory requirement.

Regarding preheating of CO_2 for use in holds, the refinement was noted with interest, the author having been content to rely on the convection air currents and the heat of the fire serving the dual purpose of spreading and expanding the gas.

The provision of ejectors on all ships was another ideal which the author could recommend but could not insist upon. Since their emergency use was much more likely to be necessary in port it would be more economical to provide such an item in the port fire fighting equipment where it would be available for any ship.

The spread of fire through bulkheads by means of paint and inflammable insulation was referred to by other speakers in the discussion. Drencher pipes were an expensive method of preventing fire spread. It was considered in some older ships as an alternative to insulation but in the case of machinery space casings the successive steps from the narrow skylight to the full beam of the ship at different levels rendered the idea impracticable. It was rarely that bulkheads, particularly in machinery spaces, were unobstructed for their full height. The picture of cargo fires at sea spreading relentlessly from hold to hold was fortunately not borne out by the large number of instances where steam and gas smothering had either extinguished the fire or held it in check quite successfully. The need for securing comparatively unstable oil heating units was fully concurred in and the production of a more stable model would be an advantage since they were often required to be semi-portable.

Captain Colbeck provided a lengthy study of the stability problem and in conjunction with the paper by Mr. Steel referred to in the author's paper, had provided a good opportunity for some typical calculations of likely cases. Regarding means of transfer of oil fuel from one double bottom tank to another, this was a requirement in all passenger ships.

In reply to Mr. Granlund, the author should more correctly have used the word "incombustible" as defined in the passenger ship construction rules rather than "fire resistant".

On the inferences to be drawn from the statistics on accommodation fires, the author pointed out that the heading "accommodation and stores" included all spaces which were not for cargo or machinery. Thus many of the fires listed were not cabin fires and in fact galley fires were responsible for many of the entries. To show accommodation and stores fires in their proper perspective it was necessary to turn to Tables II and III, which showed that accommodation fires were the least serious of the three categories and that in nine total losses only the *Empress of Canada* was a true accommodation fire and she had no sprinklers and the fire prevention before and after the fire left much to be desired. A special survey of actual cabin fires over the same period as the tables showed only four cases in cargo ships where more than one cabin had been destroyed so that the author's opening paragraph on accommodation fires was considered to be a fair statement and might help to explain why the Ministry had not taken the greater lead that Mr. Granlund had suggested. The author agreed that so long as the careless smoker was an accepted risk, accommodation would be safer if made entirely of noncombustible material which, however, still left the smoker to burn in his own bedclothes. He would hesitate to suggest inflicting the full passenger ship requirements on all cargo ships but could assure Mr. Granlund that the matter was under constant review. Four lives were lost in cargo ship accommodation fires in the period reviewed, three by smoking and one from an oil heater.

In answer to Cdr. Hutcheson the author referred to the reply to Mr. Granlund and to the last paper in the symposium. On the question of relative fire risks in accommodation and machinery spaces, the author disclaimed professional bias towards the latter by a further examination of the tables. Thus, while machinery space fires only ranked third in Table I, they easily topped the number of serious fires in Table II and in Table III accounted for the loss of five of the nine ships listed, an average of one British ship lost by machinery space fire every year. Furthermore, Table II showed that three-quarters of the serious machinery space fires occurred at sea where danger to life loomed large.

The author referred to tankers in his reply to Mr. Mear but further explained to Cdr. Hutcheson that the tables included all fires in machinery and accommodation spaces in tankers but excluded tanker explosions. He had not previously considered to what extent incombustible accommodation would save life in a tanker whose cargo caught fire due to collision. The importance of closing poop and bridge front doors was generally understood.

The author concurred in Captain Kippen's remarks on the desirability of providing a fresh water supply within the ship for the sprinkler pump suction when in dock, power being supplied by the emergency generator or the shore when auxiliary generators were shut down. Captain Kippen scored a point over the use of the nearest appliance which the author gracefully acknowledged. On all other points the author was in agreement with Captain Kippen's ideas, which were in many ways in advance of present statutory requirements, such requirements, as always, being based on a minimum standard.

Dr. Lawrence deserved the thanks of authors and readers alike for his explanation of the present position in the search for the ideal fire-retardant paint.

Regarding the packing and carriage by sea of what were termed generally "dangerous goods", the author assured Rear Admiral Mark-Wardlaw that a very close watch was kept on all new substances, including radioactive materials, and all incidents of any importance were carefully studied by a Ministry Committee which was in close touch with industry and had expert advice always available. This Committee was in close touch with the activities enumerated.

The author was in full agreement with the remarks by Mr. Pengelly, Mr. Serbutt and Mr. Wood. Undoubtedly a sense of smell ought to be a qualification for the post of fire patrolman or watchman and if such a man could also be a non-smoker his sense of smell would probably be keener and certainly more efficient.

The author concluded his replies to the discussion by thanking all those who had taken part, whether by giving the benefit of their experience and ideas or by suggesting improvements in various directions, bearing in mind that they should at all times be reasonable and practicable. All this information was most valuable in assisting the author in giving the best technical advice in his official capacity.

Reply to the Discussion on "Principles of Fire Organization in Ships at Sea and in Port"

The discussion, extending to some 27,000 words, while gratifying to the authors as evidence of the interest evoked, also brought to light an ever-expanding range of pertinent considerations when all types of ships in all circumstances were included. So great was the diversity of emphasis revealed that there would seem to be room for specialized papers devoted to such classifications as passenger ships, tankers, refrigerated ships and dry cargo ships as well as fires in machinery spaces.

Within the wide field covered, the importance of the human factor was stressed by many contributors. In regard to human fallibility there were two main divisions depending on its sequels: those which caused an outbreak and those which prevented the outbreak from being brought under control.

It was the first of these groups which attracted most attention. The problem of careless smoking in all its aspects was tackled by many speakers and the author would wholeheartedly endorse the recommendations made by Cdr. Grey and Mr. Wray. The exponents of the fireproof ship were quick to attack the presence of combustible matter and the author's advocacy of the use of wood in accommodation for certain purposes. Cdr. Hutcheson put this very well in his prescription for trying to separate the fool from his folly by "building into the ship every proved precaution which could be afforded and which did not interfere with her basic design and earning capacity". To this the author would agree, but the snag lay in the interpretation of "afford" and "earning capacity" which concerned an owner's issue more fundamental than the achievement of technical perfection. Similarly, Mr. Greenslade found the presence of any wood in the accommodation of a passenger ship completely inconsistent with the author's contention that "the ship herself . . . is wholly designed . . . to offer the greatest resistance, consistent with her functions, to the hazards of the oceans, including fire at sea". It was only too easy in the pursuit of technical perfection to lose sight of the primary function which the ship must fulfil, namely, to trade effectively for her owners. In this connexion the author was grateful for the understanding shown by Mr. Strother-Smith and Mr. Wray, but he was unable to concede any validity to Mr. Greenslade's suggestion that, by the exclusion of combustible matter, as far as practicable, he would have taken care of the fallibility of man, or would have frustrated "the relaxed tendencies of the human element". It was precisely these "relaxed tendencies" which could produce very real peril and were positively solicited which the assumed fireproof characteristics of a ship became known, or worse still, were actively publicized. In this the author was glad to have the vigorous endorsement of Mr. John Brown and of Sir Austin Anderson with his pithy and pertinent comment that "to believe in an incombustible ship would be just as dangerous as to believe in an unsinkable ship".

The counterpart to the foregoing was displayed by Mr. Chadwick in stating his belief that absence of fires when handling petroleum spirit was due to realization of the risks to personal safety involved. Mr. Sohoni really made the same point when he suggested that the absence of personal risk from a fire in port was responsible for the attitude of "couldn't care less" which then obtained, whereas at sea the mental picture of the boy standing on the burning deck and unable to step nimbly ashore exercised a deterrent effect.

The second group of sequels, namely those which resulted in a fire getting out of control, also attracted forthright comment. Mr. Stevens and Mr. Beattie stressed the need for personal efficiency in fire fighting. Mr. Wray cited fire extinguishers found to be empty. Captain Colbeck spotlighted lack of stability data. The author agreed with Mr. Sohoni that the actual fire fighter was often unjustly blamed. Responsibility for foresight, organization, training and maintenance rested higher up. As an example, the author admitted that prior to these papers he had not appreciated the great potentialities of the shaft tunnel when developed as a base from which to attack machinery space fires. As propounded by Mr. Welch, pursued by Mr. Arrowsmith and Mr. Chadwick, and described in detail by Mr. MacTier, the virtues were obvious.

The conclusions reached by the author on the interrelated aspects of the human factor and combustibles might be summed up as follows:—

(i) Awareness of the fire shadow, and a proper respect for it, was and would remain, an indispensable component in fire organization. Anything which weakened that respect not only invited fire outbreak but might render worthless the excellent provisions made for quelling it.

(ii) Reduction of combustibles, wherever practicable, was an objective agreed by all, but it could never be a panacea, or justify any relaxation in the need for awareness. Practicability, in any given instance, was not always a matter capable of decision on technical grounds alone.

Mr. Greenslade's suggestion that fire grading according to susceptibility assessed on structural features might be of interest to underwriters was an instance of an oft-repeated theme. Underwriters invariably welcomed any safety measures over and above those required by classification or Ministry requirements; but risk rates were only affected indirectly, if and when the owner's record improved. This viewpoint, moreover, would be completely logical in the present context, since fire grading would necessarily omit the human factor which could, as these papers showed, be decisive. A grade one ship allied to an indifferent human standard was a far worse risk than a thirty-year-old grade five ship in first rate hands.

As expected and hoped, the author's wilful if tentative suggestions regarding aluminium alloy produced interesting reactions. Mr. Firth and Mr. Granlund canvassed the possibilities of uninsulated alloy from different angles, the former along the author's lines and the latter as a possible sequel to the exclusion of combustibles. Mr. Chadwick, though not specifically referring to alloy, advocated the provision of "dry drencher pipes above each side of the top of a bulkhead" to prevent by water cooling the transmission of fire across the boundary. Like the author, Mr. Lenaghan was afraid lest regulations should delay the use of alloy in situations where insulation was not strictly necessary. Mr. Wood thought that the virtue of water from a sprinkler near a heated alloy bulkhead would be its influence on the rate of heat generation. Dr. West, speaking *ex cathedra,* pointed out that in the crucial example of a stressed column, an additional 2½ minutes of protection, by insulation, or other means, was all that was needed to give alloy the same fire resistance as steel. He also admitted that the very much higher thermal conductivity of alloy might assist in delaying temperature rise to dangerous levels. It seemed to the author that there still remained rather wide gaps in their knowledge of the extent to which heat exchange beween water and alloy could obviate the need for insulation.

In conclusion, the author would like to express his appreciation of the invitation to take part and of the leniency accorded to him over the matter of the asbestos pants.

Reply to the Discussion on "Naval Procedure in Relation to Fire Organization"

Mr. Carter and Captain Hogger had confined their remarks in reply mainly to points which had a direct bearing on their own paper. They wished, however, to extend their thanks to all those who had taken part in the discussion, from which they had learned a great deal and which they felt had added considerably to the value of the symposium.

Messrs. Hayward and Wray both referred to the use of small diameter hoses. The Admiralty was very much aware of the advantages to be gained in using smaller diameter hoses in ships, especially below decks, and it was hoped to adopt a size of not greater than $1\frac{1}{2}$ inches for use in congested spaces. For weatherdeck use, it was probable that the standard size would become 2 inches as against $2\frac{3}{4}$ inches used at present.

Consideration was being given to the use of hose reels, as suggested by Mr. Hayward, but only for machinery spaces. The disadvantage of these appliances was that they operated off a fire main, which meant that in the event of action damage affecting the piping, a proportion of the first-aid fire fighting equipment might easily be lost. There was a good case for the retention of portable extinguishers distributed throughout the ship.

Mr. Wray also commented, like many others, on the need for stern action in the interest of fire protection when men were found smoking in unauthorized places. The authors concurred that disciplinary action was necessary when men were found smoking in an improper place. Nevertheless, a man who was prepared to run the risk of blowing himself up was unlikely to be deterred by any reasonable punishment and one could hardly make smoking a capital offence.

Referring to the remarks of Cdr. Oliver and Lieut.-Cdr. Ranken about difficulties in the use of foam for bilge fires in engine and boiler rooms, the existing arrangements for introduction of foam into machinery spaces by means of two or four fixed inlet tubes, depending on the size of the ship, were being reviewed in the light of the very much increased subdivision in the bilges. It was envisaged that fixed installations would be provided with a grid of piping by means of which foam could be introduced to each separate bay. This would mean that foam would reach a fire in the bilges, wherever it was, in the shortest possible time.

Admiralty departments were aware of the inert gas system fitted in m.v. *Oti,* but in view of the initial time lag in extinguishing effect did not consider this to be suitable for machinery spaces in H.M. ships.

The advantage of an automatic cut-off to fuel supply, commented on by Cdr. Walmsley, was appreciated. The difficulty was that in a warship there were occasions when loss of mobility was unacceptable even though there was a boiler room fire. It was a risk which might have to be taken. The fuel could, of course, be shut off from outside the boiler room, but as this involved stopping the ship and possibly loss of power to the armament, the command must be informed first.

Cdr. Walmsley's contribution to the discussion also included a reference to the case of a galley fire being transmitted through ventilation trunking to a cabin some way off. In Naval vessels, all galley exhaust ventilation trunks were to be fitted with a portable grease filter, a grease trap, and a hinged baffle plate. Requirements for the baffle plate were that it must be operable by a lever within easy reach of a man standing on the deck. The lever must also be as remote as possible from the source of the fire. In very small galleys this would normally mean that the lever must be positioned just outside the compartment.

In his discussion on breathing apparatus, Captain Shelford drew attention to the Salvus which was Royal Navy usage. It had been realized for some time that the Salvus had certain disadvantages. Unfortunately, existing production models of compressed air apparatus were unsuitable for warship use because of their size and endurance and an entirely new design had been found necessary. This naturally took time but delivery of a prototype model was expected soon.

The authors did not agree with Captain Shelford's condemnation of the smoke helmet as used in the Royal Navy. This consisted merely of a respirator or similar type face piece attached to a pipe containing a suitable non-return valve. It was extremely simple to use and could be tested by kinking the hose in the hand and breathing in. Any leakage would be immediately apparent.

Lieut.-Cdr. Ranken raised a number of points of Naval interest in his remarks. He related an experience where the rubber joints of a suction line became burnt and prevented any water used for fire fighting from being pumped out again to safeguard stability. This was not likely to happen in newer ships since in 1955 it was approved to fit a jointing material of compressed asbestos fibre in lieu of rubber insertions.

Referring to the suggestion that the Admiralty publication, "Ship Fire Fighting Manual", might be released for sale to all seafaring men, this manual in its present form was not suitable for issue. It was, however, in process of being rewritten and if the new edition were likely to be of general interest, it was possible that consideration could be given to its sale to the public.

On the question of co-operation with shore fire brigades for ship fire fighting when in port, the responsibility of the commanding officer where a fire occurred in port was covered in existing regulations. Briefly, these stated that the dockyard fire brigade and the local authority fire service must be informed, but that the commanding officer remained responsible throughout for the measures taken. This was, of course, different from the procedure in merchant ships. It was emphasized that there should be close co-operation between ships and fire officers.

Lieut.-Cdr. Ranken and others referred to the use of metal furniture, etc., in modern warships. The majority of ships fitted out since the war had been equipped with metal furniture. In officers' quarters, furniture was of aluminium with an imitation wood-grained finish. Only in commanding officers' apartments and in wardrooms had wood furniture recently been reintroduced, the wood being fireproofed. In ratings' accommodation, tables and stool tops were of fireproofed wood, but everything else was of steel or aluminium, tubular construction being used for chairs and bunks. Doors throughout the ship were of metal, but door frames for cabins and offices were of fireproofed wood. Other door frames were either aluminium or steel according to the type of bulkhead.

Mr. Haywood suggested that there were certain snags in the use of fireproofed timber. The value of fireproofing all timber might be said to lie in the fact that it rendered the timber so treated less likely to start a fire or to assist in its propagation. Fire-retardant treatment might perhaps be regarded as a first-aid measure in one sense. When it came to wood in large sections, especially hardwood, there seemed to be a good case for not giving it a fire-retardant treatment, but there was no doubt that any timber of light scantling could readily start a fire if a source of ignition were present and in these instances fire-retardant treatment was of considerable value.

Mr. Haywood also drew attention to the need for ensuring that fire fighting equipment should work when the fire main pressure was low and instanced the in-line inductor which it was proposed to use on the flight deck of aircraft carriers.

Whenever new equipment was introduced for use in association with the fire main, every effort was made to ensure that it would operate at a reasonably low pressure which would take into account the effect of possible damage. In the case of the in-line inductor, although the specified working pressure on the inlet side was 100lb. per sq. in., the appliance had been operated at a pressure as low as 40 with fairly satisfactory results. However, the in-line inductor would only be used in carriers fitted with a separate flight deck fire main and as this was supplied from four independent pumps well separated throughout the ship, there was reason to believe that pressure should be reasonably high at all times.

Mr. Arrowsmith enquired whether the Royal Navy had devised any means for refilling CO_2 extinguishers without aid from ashore. Consideration had been given to this problem, but weight, space and maintenance difficulties ruled out the provision of a special compressor for the purpose. Some spare extinguishers were carried and it was believed that this would be sufficient.

The authors were indebted to Messrs. Bryant, Pengelly and Stevens and to Dr. Lawrence for their constructive remarks on particular aspects of Naval fire fighting and prevention. These contributions called for no detailed comment in reply.

Reply to the Discussion on "Research in Relation to Ship Fires"

Taken together, the contributions to the discussion summarized the trend of the symposium so effectively that Mr. Clarke thought there was no need for further comment of that kind. Some further explanation appeared to be necessary through misconceptions in connexion with one or two points in the paper on Fire Research, but before offering that it might be well to emphasize one of the important practical outcomes of the symposium.

Mr. Welch rendered a signal service by directing attention to the outstanding importance of fires in machinery spaces. A recent article from the insurance world had expressed concern over these fires. If a single step were to be taken as the result of the symposium the most profitable would undoubtedly be a concentrated attention on the reduction of the hazard of fires in machinery spaces. With the knowledge already available this was within the realm of possibility.

From the nature of several contributions to the discussion it would appear that the concept of fire grading was not sufficiently explained. It would not be questioned that damage by fire was caused by the burning of combustible materials, and that it was useful to have some quantitative expression of the amount of combustible material capable of doing a certain amount of damage. The concept of "fire load", which was now in general use for this purpose by fire engineers on both sides of the Atlantic, had proved to be invaluable in connexion with fires in buildings; it did not carry any implication about "fireproof ships" (so-called), but was simply a step in orderly thinking. It was interesting that the symposium produced so many signs that the value of the concept in connexion with ships was receiving recognition.

Mr. Granlund might have misinterpreted the purpose of the fire-resistance tests which were carried out by the Joint Fire Research Organization. The aim was to assist manufacturers in their efforts to design more efficient structures; by defining only function and performance instead of laying down rigid structural requirements, full scope was left for the ingenuity of the designer and engineer. The applicant bore the full economic cost of the test so that there need be no fears on behalf of the taxpayer. As a rule manufacturers were only too glad to promulgate the results of tests, and the Fire Research Organization was always willing to put enquirers in touch with them.

An aspect of fire grading to which little reference was made, but which clearly deserved attention, was that of means of escape. The importance in at least one fire was implied by Mr. Beattie.

Aluminium, and other new materials that were coming into use, had a proper place in ship construction. It was, however, misleading to argue from the basis of their conductivity or thermal capacity without due regard to the large quantities of heat that could be liberated in a fire of any importance. This should not deter the adventurous designer from giving full consideration to the use of a new material; the only requisite was that he should seek full information about the protection needed.

It was reassuring to find so much agreement on the reliance to be placed on well-maintained sprinkler installations, and he had nothing to add to the statement made in the paper.

Mr. Firth advised caution about accepting results gained from experiments on the extinction of fires on a small scale. In this he was right but the fundamental information on which a satisfactory understanding and on which future development must largely depend could not be obtained in any other way. It was necessary, of course, to extend such work by companion experiments on a large scale. It was hoped to publish an account of such experiments, including some new information, in the near future.

He hoped his reference to small extinguishers did not give a wrong impression. They were an invaluable form of fire protection. His concern was to emphasize the fact that they might be used by untrained people and reliance should only be placed on their dealing with relatively small fires.

Appliances containing carbon dioxide, dry-powder, or any of the vaporizing liquids, should only be used to protect against fires for which they were more than sufficient, and in fixed installations that were "tailored" to the specific risk. It was dangerous to rely on these agents unless it were known that there was ample reserve. A fire that was 9/10ths extinguished when the agent ran out regained its original size in a flash; on the other hand a fire that was 9/10ths extinguished by foam stayed 9/10ths extinguished for a long time, and gave some respite while reserves were mustered.

In the view of the Department of Scientific and Industrial Research and of the Fire Offices' Committee, carbon tetrachloride should never be used in enclosed spaces and where any of the agents mentioned above had been used it was essential that enclosures should be fully ventilated before entry was permitted. It should not be forgotten, as Mr. Wilson pointed out, that dead spaces below floorplates, or crankcases, could be danger spots.

There were several expressions of hope that some heavy vaporizing liquid might be discovered that would form a heavy blanket to extinguish a fire. The difficulty, of course, with any extinguishing agent was to get it to the seat of the fire as soon as possible. It would be realized that the fixed installation offered the best chance of success and if a fixed installation were available, a water spray (e.g. sprinkler) left little to be desired.

In view of the many references to breathing apparatus, perhaps it should be mentioned that the concensus of informed opinion was that personnel who must wear breathing apparatus should be carefully trained. Many experts thought that they should be selected for training and that many men were unsuited to the task.

Considerable stress was laid on the importance of the human element in fire protection, and this should not be underrated. Fire protection depended on a number of closely interrelated factors, not the least of which was the human element. The members present were concerned partly with existing ships, partly with new ones, and partly with long term aspirations. It would perhaps be agreed that the long-term aim should be ships in which as little reliance as possible was placed on the human element, and that the best use should be made of design and "tailored" installations to ensure early detection and extinction should an outbreak occur.

Finally, several interesting references had been made to the effect of the water used in fire fighting on the stability of the ship. This, and the possibility of a close control of ventilation, were two points that designers should keep well in mind.

Mr. Hodges thought that Sir Austin Anderson stated quite rightly that to believe in an incombustible ship would be just as dangerous as to believe in an unsinkable ship. However, he and other speakers agreed that as much progress as was practicable should be made in reducing the amounts of combustible material in passenger ships. Mr. Serbutt in his contribution stated the position very well, and in particular he emphasized that if cabin bulkheads were of incombustible material, there was the double advantage that not only was the fire subdivision improved, but, at the same time, the amount of combustible material was reduced. Of course, this was another aspect of the point made by Sir Austin Anderson that the number of B.t.u. of combustible material did not of itself give a complete and true picture of the risk of spread of fire.

The development of air conditioning in passenger ships mentioned by Sir Austin Anderson was a step in the right direction as regards fire risks and it might also be pointed out that, if side scuttles could be thereby always kept closed at sea, it would be an important contribution to the safety of ships in the event of side collision damage causing flooding and, therefore, list and trim.

Mr. Lenaghan mentioned the use of aluminium alloys in the construction of passenger ships. This had raised problems in connexion with the fire risk not quite so simple as appeared to be suggested by Dr. West, but, nevertheless, capable of being dealt with in an acceptable way. The author took this opportunity of thanking Dr. West for all the research work he had sponsored for obtaining data for dealing with this problem.

The contribution by Mr. Brown to the discussion was particularly valued since his professional duties and his membership of the Fire Research Board kept him constantly in touch with fire problems and the work done at the Fire Research Station in dealing with them. The thanks of all concerned with fires on ships in port were due to him for his work in presenting the problem of stability in relation to fire fighting to fire officers in Glasgow. This was a difficult problem, and deserved the closest study by naval architects, both in shipbuilding and in shipowning organizations. Captain Colbeck emphasized this in his contribution. The tests at the Fire Research Station on Class A and B divisions were, of course, made under controlled conditions, but the application of the results to actual ships raised many difficult practical problems. The co-operation of the shipbuilders in dealing with these problems had been much appreciated by the author, as in many cases they involved entirely new techniques. The difficulty mentioned by Mr. L. G. Stevens was pertinent in this connexion, that was, that caused by the passage of electric cables, etc., through fire-resisting divisions. By and large, however, the author would be more concerned about the superfluous holes often drilled in fire-resisting bulkheads and liable to be left unplugged than those through which cables were led, provided properly designed glands were fitted. With large cables, a steel trunk fitted on each side of the bulkhead and packed and sealed with non-combustible material had been used, but no official tests of them had been made.

The information given by Mr. A. Audigé on the latest French Regulations was much appreciated. He rightly pointed out that the position in regard to the supply of fire-resisting and incombustible materials was quite different now from what it was at the time of the 1948 Safety Convention.

With regard to the statement brought out by Commander Hutcheson that with rigid asbestos boards it was difficult to provide adequate insulation on one side of a bulkhead if the boards were fixed directly to it, this, of course, applied to steel class A divisions. It was a mere statement of fact and was not intended to imply that the difficulty could not be overcome by proper design.

In conclusion, the author wished to thank all the contributors to the discussion for all their constructive comments which added so much to the success of the symposium.

INSTITUTE ACTIVITIES

Minutes of Proceedings of a Joint Meeting Held at the Institute on Tuesday, 23rd October 1956

A Joint Meeting of the Institute of Marine Engineers and the Institution of Naval Architects was held at 85, The Minories, London, E.C.3, on Tuesday, 23rd October 1956, at 10.30 a.m. Mr. T. W. Longmuir (Chairman of Council, I.Mar.E.) was in the Chair and was supported by Mr. H. E. Steel, C.B.E. (Member of Council, I.N.A.). There were 207 members and visitors present.

The four papers contributed to a symposium on "Fires in Ships" were presented by the authors, as follows:

"Survey of the Causes and Methods of Extinction of Fires in Ships", by F. J. Welch (Member, I.Mar.E.), M.I.Mech.E.

"Principles of Fire Organization in Ships at Sea and in Port", by Lieut.-Col. A. G. Bates, D.S.O., M.C.

"Naval Procedure in Relation to Fire Organization", by L. T. Carter, B.Sc., R.C.N.C. (Member, I.N.A.), and Captain H. C. Hogger, D.S.C., R.N.

"Research in Relation to Ship Fires", by S. H. Clarke, C.B.E., M.Sc., and S. A. Hodges, M.B.E. (Member of Council, I.N.A.).

After a break for lunch, the meeting was resumed at 2.30 p.m. for the discussion of the papers, to which twenty-three speakers contributed. Mr. Steel proposed a vote of thanks to the authors which was accorded by acclamation. The meeting ended at 5.50 p.m.

Section Meetings

Kingston upon Hull and East Midlands

Annual Dinner

The Sixth Annual Dinner of the Kingston upon Hull Section was held in the reception room of the Guildhall at Kingston upon Hull on Friday, 9th November 1956, when a very pleasant evening was enjoyed by members and friends.

Mr. G. H. M. Hutchinson (Chairman of the Section) presided and the principal guest was the Lord Mayor of Kingston upon Hull, Alderman H. Kneeshaw, J.P. Mr. Bryan Taylor, B.Sc.Eng. (Member of the Section Committee) proposed the toast to the City and County of Kingston upon Hull, to which the Lord Mayor responded. The toast to the Section was given by Rear-Admiral F. E. Clemitson, C.B. (Vice-Chairman of Council) and Mr. Hutchinson replied. Mr. J. G. Charlton (Vice-Chairman of the Section) proposed the toast to the guests, to which the response was made by Mr. A. L. Cochrane, the Selby shipbuilder.

About 170 people attended the dinner, amongst whom were the Sheriff of Kingston upon Hull, Mr. E. A. Brocklehurst, Mr. C. Cameron-Kirby (President of the Hull Association of Engineers), Mr. E. Jones (Principal of the Kingston upon Hull College of Technology), Mr. G. Strong (Society of Consulting Marine Engineers and Ship Surveyors), Mr. E. Milner (Institution of Electrical Engineers), Mr. J. Calderwood, M.Sc. (Honorary Treasurer), Mr. F. C. M. Heath (Vice-President), Mr. D. G. Alcock (Member of Council), Messrs. A. Addy, F. R. C. Cookson, H. F. Hesketh and W. A. Rhodes (Members of the Section Committee) and Mr. C. J. Potter (Honorary Treasurer of the Section).

Senior Meeting

The second meeting of the session was held on Thursday, 22nd November 1956, when Mr. W. H. Falconer (Associate Member) presented Mr. A. G. Arnold's paper on "Some Experiences in Vessels Equipped with Two-stroke Harland and Wolff Opposed Piston Diesel Engines Using Boiler Oil". Mr. G. H. M. Hutchinson (Chairman of the Section) was in the Chair and the meeting was attended by seventy-six members and friends. An interesting discussion followed the lecture, many of the questions being asked by students and apprentices. Following the closing remarks by the Chairman, a vote of thanks was accorded to Mr. Falconer which was proposed by Mr. F. C. M. Heath (Vice-President) and seconded by Mr. W. R. Evans.

Scottish

Senior Meetings

The first meeting of the 1956/57 session was held at the Institution of Engineers and Shipbuilders in Scotland, Glasgow, on Wednesday, 10th October 1956, at 7.30 p.m., the Chair being taken by Mr. R. Beattie (Member of Committee).

Captain N. J. H. D'Arcy, R.N.(ret.) (Chairman of the Scottish Section), gave an extremely interesting talk on "General Observations on Marine Machinery" before some 100 members and visitors and an enthusiastic vote of thanks was accorded to the speaker on the proposal of Mr. G. Mead.

A further meeting was held at the Institution of Engineers and Shipbuilders in Scotland, Glasgow, on Wednesday, 14th November 1956, at 7.30 p.m. Captain N. J. H. D'Arcy, R.N.(ret.) (Chairman of the Scottish Section) presided and introduced Mr. B. Hildrew, M.Sc. (Associate Member), who gave a most interesting paper on "Balancing of Marine Reciprocating Engines" before an audience of eighty-five.

A vote of thanks to Mr. Hildrew was proposed by Mr. J. Robson, after which members and visitors adjourned for light refreshments.

Junior Meetings

A Junior Meeting was held at the Institution of Engineers and Shipbuilders in Scotland, Glasgow, on Wednesday, 24th October 1956, at 7.30 p.m., Mr. A. Campbell presiding in the unavoidable absence of Captain N. J. H. D'Arcy.

Mr. H. C. Gibson (Associate Member) gave a lecture on "The Junior Engineer's First Trip to Sea" before some sixty members and students and seventeen speakers took part in the lively discussion that followed. A vote of thanks was heartily accorded to Mr. Gibson on the proposal of Mr. H. Ingram.

This lecture was repeated at Queen's College, Dundee, on Thursday, 25th October 1956, at a joint meeting with the Dundee Institute of Engineers. The Scottish Section, headed by the local Vice-President for Dundee, Mr. W. Gardiner, was welcomed by Mr. J. W. Budge, President of the Dundee Institute, who expressed his appreciation of the Scottish Section visit to Dundee.

The meeting closed with a vote of thanks to Mr. Gibson for his instructive paper.

Sydney

Annual Dinner

The Annual Dinner of the Sydney Section was held at the

Wentworth Hotel, Sydney, on Thursday, 25th October 1956. There was an attendance of one hundred, comprising fifty-nine members and forty-one guests. The official guests included Mr. G. F. Auberson (Babcock and Wilcox, Ltd.), Mr. C. Boden (President, Institution of Naval Architects, Australian Branch), Mr. A. Denning (Director of Technical Education, New South Wales), Mr. L. G. Gibbons (Australian Shipbuilding Board), Mr. T. Nell (Lloyd's Register of Shipping) and Mr. R. W. J. Mackay (President, Institution of Engineers, Australia).

Guests of the members present included representatives of the Navy, Merchant Navy, Lloyd's Register of Shipping, Australian Shipbuilding Board, Department of Labour and Industry, shipowners and their superintendents and representatives of companies interested in the supply of equipment to ships.

The local Vice-President, Eng. Capt. G. I. D. Hutcheson, R.A.N.(ret.), presided at the dinner. After the Loyal Toast, the toast of the Institute of Marine Engineers was proposed by Mr. R. W. J. Mackay; the Chairman responded on behalf of the Sydney Section. The toast of the Guests was proposed by Mr. J. Ward and replied to by Mr. B. Foggon. The dinner was again a most successful function and the whole evening a great success.

West Midlands

A General Meeting of the West Midlands Section was held at the Birmingham Exchange and Engineering Centre at 7 p.m. on Thursday, 11th October 1956. Mr. H. E. Upton, O.B.E. (Chairman of the Section) was in the Chair and the meeting was attended by seventy-four members and guests. In the unavoidable absence of Mr. L. Baker, D.S.C. (Member), Dr. J. Cheetham presented an illustrated paper entitled "Oil Burning for Burners".

The author commenced by referring to the basic principles of oil burning, then described in some detail the many and varied factors involved when designing oil burning equipment, both for land and marine installations. He concluded his excellent lecture by giving performance and operating details of the types of oil burning equipment at present in use and discussed the relative merits of the conventional units and the more recent rotary type burner.

Some twenty members took part in the ensuing discussion and the Chairman expressed the Section's appreciation to Dr. Cheetham for a very interesting lecture. The meeting ended at 9.30 p.m.

Junior Meetings

Acton Technical College

A Junior Lecture was given at Acton Technical College on Wednesday, 7th November 1956, at 7 p.m. Mr. W. Hogbin (Member) was in the Chair and the students present were appreciative of the lecture given by Mr. R. S. Hogg (Member) on "Launching of Ships".

Borough Polytechnic

A Junior Meeting was held at Borough Polytechnic on Friday, 16th November 1956, at 6.30 p.m., which was attended by sixty students. Mr. J. E. Garside, Ph.D., M.Sc.Tech. (Principal) was in the Chair. A lecture was given by Mr. J. H. Gooch, B.A., on "Modern Marine Steam Turbines" and the students found that the interesting subject matter integrated very effectively into their general theoretical studies.

East Ham Technical College

On Tuesday, 6th November 1956, at 7.30 p.m., a meeting was held at East Ham Technical College. Mr. G. Pember, B.Sc. (Principal) was in the Chair and Mr. D. G. Alcock (Member) was the representative of the Institute Council at the meeting. There was an attendance of approximately fifty students to hear a very successful lecture by Mr. J. H. Gooch, B.A., on "Modern Marine Steam Turbines".

Poplar Technical College

A Junior Lecture entitled "Modern Marine Steam Turbines" was given by Mr. J. H. Gooch, B.A., to an audience of approximately 130 marine engineer officers and engineer cadets at Poplar Technical College on Wednesday, 31st October 1956. The lecturer covered a wide field and referred to types of turbine already in use and also to recent developments in the double casing turbine and the single cylinder turbine. He also described the gearing, glands and condensers.

After dealing very ably with a number of questions from the audience, the lecturer showed a film of the manufacture and assembly of turbine blading.

Mr. C. Taylor-Cook, B.Sc. (Member), Principal of the College, was in the Chair, and a vote of thanks was proposed by Mr. I. S. B. Wilson (Member) who also drew attention to the advantages of membership of the Institute.

West Ham College of Technology

At a meeting held on Thursday, 1st November 1956, at 7 p.m., at the West Ham College of Technology, Mr. J. E. Garside, Ph.D., M.Sc.Tech., gave a lecture on "Metallurgy in Marine Engineering". Mr. H. C. Oliver, Head of the Engineering Department of the College, was in the Chair and there was an attendance of eighty students.

The obvious interest in the lecture was shown by the numerous questions submitted at the close, which were all answered in a very helpful way by the speaker.

Student Section

A meeting of the Student Section was held at 85, The Minories, London, E.C.3, on Monday, 15th October 1956, at 6.30 p.m., when a paper entitled "The Junior Engineer's First Trip to Sea" was presented by Mr. H. C. Gibson (Associate Member). Seventy-one members and visitors were present and twenty speakers took part in the discussion.

A vote of thanks proposed by the Chairman was accorded by acclamation. The meeting ended at 8.40 p.m.

Election of Members

Elected 12th December 1956

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Zain-ul-Abi-Din Abid, Cdr., P.N.
Eric Hans Abt
Antonios Apostolou
Ivan Oldham Backhouse, Capt., R.N.(ret.)
Robert Geoffrey Beldam, M.A.
Tydwal Rhys Charles
William Armstrong Clay
Sidney Victor Collins, Lieut., R.N.
Philip Iredale Corner
Robert John Craig, Cdr.(E), R.C.N.
Roger Alexis Alfred Fressignaud
Hideo Fujita
William Fyffe
Jack Roslyn Gillies
Joseph Hall
Claude Warren Hayes
William Robert Haygarth
Laurence Walter Jane, Lieut.-Cdr., R.N.
George McFarlane
Andrew James McLuckie
George Alexander Mitchell
John Edwin Perry
Christos Rados
Kenneth Reynolds
John Stuart Robinson, M.A.
James Alexander Rolfe, Lieut., R.N.
Stanley Bowden Rooke
Kenneth Edmund William Russell-Hardy
John Edward Ryan
Arthur Derwent Sharpe, Lt.-Cdr.(E), South African Navy
Eric Henry Simmonds
George Edward Tottey

Adolf Roderick Vall
Conrad Edward Howe Verity
Edward Vener Webster
John Wilson
Tsadok Zakon

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Herbert Bruce
John Reid Burns
James Roland Callow
Leonard Carnes
Nitibhusan Chakraborty
William Glanville Cooper
Peter Robert Croft
George Richard Davies, D.F.C., M.Sc.(Eng.)
Gordon Henri Dodd
Colin Evans
Geoffrey Gordon Alfred Fox
Samuel Gordon
John Donald Grant
Owen Thomas Griffith
William Paterson Grindlay
Arthur Hunter
John Huntley
Stanley Jolley
Henry Christian Larsen
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George Herbert Edwin Mason
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Douglas Edginton Rothnie
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Robert Short Stevenson
Ole Egil Strupe, Lt.-Cdr.(E), Royal Norwegian Navy
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Ralph Augustus Sutherland
Vengalil Koshy Thomas
Raymond Thompson
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Maung Soe Aung
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James Payne Bullock
Oswald Burgess
Morris Carrick
Sankar Das Gupta
Robert Nisbet Donnachie
Douglas Grant
Dennis Allen Horn
George Milne McKay
Brian James Main
Alan Potts
Rodney Brian Pound
John William Ray
Kenneth Stoddard
Abdul Haseeb Syed
James Guyan Taylor
George William Tilby
Ronald Britwell Waugh
Ronald Whitaker
Brian Wilson Yates

STUDENTS

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William Alfred Lawrence Cox
Bernard Duckett
John Anthony Gerrity
Graham Arthur Nigel Hart
Ronald Winston Ley
Graham Philip Musker
Charles Alaric Rowntree
Zafar A. Siddiqi
Ian Keith Simpson
Barry Stewart Stott
Hamish Henry Taylor
Robert Keith Taylor
John Tharme
Graham Douglas Thorburn
David Harry Thornton
Norman Richard Vyvyan Warner
Peter Wilshaw

PROBATIONER STUDENTS

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Albert Edward Armitage
David James Michael Ashcroft
Anthony Alfred Askew
Anthony George Aspinall
Ivan George Atkinson
Robert Bakewell
Erik John Bannister
Clive Anthony Barker
John Raymond Barnett
Alan Betts
Michael Anthony Blackman
Derek Bonos
Thomas Lyon Booth
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Francis P. Brady
Graham John Braye
Douglas Bright
David Edwin Brown
Frederick Percy Burns
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Cecil Elliott
John Elliott
Graham John Fennell
Derek John Fickling
Colin Fordham
Roy Gibson
Michael Robin Giordan
Michael Ernest Glover
Richard Graham
George Graydon
John Pendlebury Green
Christopher Robin Handley
Barry Dowell Hawker
William George Hayes
Ian Michael Henderson
Robin Hesketh
John Hesketh Heywood
Anthony William Higham
Jack Hilton
Robert Hudson
Edward Michael Perronet Hughes
Jeffrey Hutt
John David Ireland
Bernard Edward James
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Jack Jenkins
Colin David Jupp
Malcolm Robert Marjoribanks Kean
Maurice Lamb
Peter Edwin Lawrence
Ronald Winston Ley
John Marshall Lingard
John Robb Ritchie Linnen
James Edward Llewellyn
James Morrison McKeown
William Robert Oswald Mann
Brian Joseph Matthews
David George Michelmore
Michael Mildwater
Leslie Myerscough
John Campbell Nairn
Charles Timothy Herbert Olney
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Christopher Buchanan Plater
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Anthony John Michael Poynter
Thomas Churchill Poynton
James Price
John Stuart Ramsden
Keith Leonard Ramsden
Howard William Reid
Donald Rigby
George Clarke Scott Rollo
Frank Maclean Rowland
Laurence Roy David Saunders
Melvyn John Sims
John Songhurst
Thomas Wilson Steen
Ronald Stephenson
Ian D. Stirzaker
Roy Stopher
David Hughie Stuart
Colin Taylor
Roger Thistlethwaite
James Peter Thomas
Sidney Thorp
Lawrence Walsh
Brian Alan Warren
Norman Walter Webster
Michael Anthony Pierpoint Westropp
Keith Ashton Whalley
John Leonard Whiting
Michael David Whitney
Alan Frank Wilde
John Wilkinson
Geoffrey Gordon Williams
Alexander Simpson Wilson
John Wilfred Wood
David Charles Woodhatch
Barrie Christopher Woods
Anthony Wright
Leslie Douglas Young

TRANSFER FROM ASSOCIATE MEMBER TO MEMBER
Maurice Poole Holdsworth, M.Eng.
Kenneth Maddocks

TRANSFER FROM ASSOCIATE TO MEMBER
John Dixon Booth
Albert Edward Jillians
Philip Charles Secretan

TRANSFER FROM ASSOCIATE TO ASSOCIATE MEMBER
John Bradley Carr
William Herbert Hamilton
Edwin John Horlick, Lieut.-Cdr., R.N.
Eric Levy
George Papadopoulos
Kenneth Bert Smith
Charles William Staniforth
Christopher Edmund Stoneham, Lieut., R.N.
Raymond Frank Vincent
Gerald McNeil Windle

TRANSFER FROM GRADUATE TO ASSOCIATE MEMBER
Basil Malcolm Theodore Clark

TRANSFER FROM STUDENT TO GRADUATE
Ian James Fairley
John Ronald Stewart-Smith

TRANSFER FROM PROBATIONER STUDENT TO STUDENT
Irving Malcolm Levington
Raymond Henry Cunningham Philpot

OBITUARY

William Henry Collins (Member 5044) died on 20th October 1956, aged sixty-two. He was educated at the Hull Municipal Technical College and trained as a marine engineer and millwright in an apprenticeship with C. D. Holmes and Co., Ltd., Hull. He had seven years' sea service and obtained a First Class Board of Trade Certificate, having sailed with Messrs. Tulley and Company, Hull, Messrs. Fenwick and Company, Newcastle upon Tyne, and the Ellerman Wilson Line of Hull and Liverpool. He then joined the company of W. Collis and Company, Hull, insulating engineers and boiler cleaners, of which he became senior partner and then sole proprietor; his son, Mr. W. A. Collins, an Associate Member of the Institute, will succeed him in the business.

Mr. Collins was a member of the Hull Association of Engineers and had been a Member of the Institute since 1924.

William Ronald MacKellar Wilson (Member 10113) was born in 1904. He served an apprenticeship with D. and W. Henderson and Co., Ltd., Glasgow, from 1920/25, and then spent two years at sea in vessels owned by Furness, Withy and Co., Ltd. From 1929 he sailed with Messrs. Alfred Holt and Company, obtaining a First Class Board of Trade Steam Certificate in 1931, until in 1933 he joined the Anglo-Iranian Oil Co., Ltd.; he stayed with this company until his retirement in 1951, at which time he was Field Workshops Superintendent. Mr. Wilson died on 9th June 1956. He had been a Member of the Institute since 1944.

Eric Read (Member 12626) was a cadet at the Royal Naval Engineering College, Keyham, until he joined H.M.S. *Marlborough* as a midshipman in 1917. The following year he was serving in the destroyer *Nessus* which sank due to a collision and the whole crew had to jump for it; fortunately, in this instance, there was no loss of life. From 1921/30 he served in H.M. Ships *Royal Oak, Eagle, Voyager, Nelson* and *Norfolk*. In 1933 he was Admiralty Engineer Overseer responsible for assembling in Shanghai the China River gunboat *Sandpiper,* the only warship ever sent overseas in crates. For the next three years he was Engineer Officer of the cruiser *Durban* and then spent two years ashore as Drafting Officer at Portsmouth Barracks. From 1938/41 he served in the Far East in the aircraft carrier *Eagle* and was then transferred to the *Uganda,* in which he saw war service in the Atlantic and Mediterranean; while shelling the beaches at Salerno, the *Uganda* was hit by an aerial torpedo and it was largely due to Commander Read's efforts that, during fourteen days and nights, she was able to limp back to Gibraltar on one engine for temporary repairs. She was finally repaired in Charleston, South Carolina, and the voyage across the Atlantic in a crippled ship was very trying and uncomfortable for all concerned. After the war he was Assistant Naval Attaché in Paris and ended his naval career as Engineer Officer of the aircraft carrier *Indefatigable.* He was mentioned in despatches on three occasions. Since retiring from the Royal Navy he had been in charge of the floating dock at Falmouth Docks. He died, after a long illness, on 7th October 1956, aged fifty-seven years.

Commander Read had been a Member of the Institute since 1949.

James Baillie Sclater (Member 7040) served an apprenticeship with Slade, Dobson and Company and A. and J. Inglis, Ltd. In 1925 he joined the British India Steam Navigation Co., Ltd., as a junior engineer officer and was promoted through the various grades until he was appointed chief engineer officer in June 1947. During the greater part of his career he was employed on the Company's Eastern service and in recent years made his home in Autralia. He died on 3rd November 1956, aged fifty-two. Mr. Sclater had been a Member of the Institute since 1932.

William Henry Steer (Member 5455) died on 23rd August 1956. He served an apprenticeship from 1913/18 with R. and H. Green and Silley Weir, Ltd., and then sailed for eight years with the New Zealand Shipping Co., Ltd., obtaining a First Class Board of Trade Certificate. From 1926 until 1945 he was chief engineer with W. H. J. Alexander, Ltd. The next year he joined the Headquarter's Technical Staff of the Ministry of Works and remained in this appointment until his death. Mr. Steer had been a Member of the Institute since 1926.