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FIRES IN SHIPS

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SURVEY OF THE CAUSES AND METHODS OF EXTINCTION OF FIRES IN SHIPS

F. J. WELCH (Member I.Mar.E.), M.I.Mech.E.*

INTRODUCTION

The contents of this paper are based on a study of the reports of fires in British merchant ships which have been received through official channels during the past five-and-a-half years. While fully aware that many fires go unreported, the average of eleven reported fires per month is considered a reasonable figure from which to draw conclusions regarding modern risks and methods of extinction. The figures, to avoid the use of that unpleasant word "statistics", have been presented in various forms in the hope that readers of varied interests may find them useful.

DIFFERENTIATION BETWEEN FIRES AT SEA AND IN PORT

In most aspects of ship fires it is essential to be quite clear whether sea or port fires are under consideration since most of the circumstances are fundamentally different and the figures have been separated accordingly. A brief glance shows the not unsurprising fact that cargo and cargo space fires are less numerous at sea, when hatches are battened down and ignition from outside sources is unlikely, while in port the reverse is the case. In contrast, in the machinery spaces metal surfaces are heated and hot oil is in circulation at sea to a much greater extent than in port and if it were not for fires caused by welding and repair work in port the sea fires would exceed the port fires.

The following comments are divided up broadly to deal with cargo space, accommodation and machinery space fires separately and consideration is given to reducing the fire hazard before and after the fire occurs.

CARGO AND CARGO SPACE FIRES

With the reduction in the carriage of coal cargoes by British ships, spontaneous ignition fires in coal are now infrequent and modern knowledge and methods of extinction usually allow the ship to make port safely and obtain shore aid. Gas explosions from coal cargoes are not uncommon, however, and will be referred to later.

On an historical note it may be recorded that the captain of an American sailing ship, faced with a cargo of dangerous coal, provided himself with some carboys of sulphuric acid, some bags of marble chippings from the local monumental masons and a suitable vat, and, with the aid of his sailmaker and carpenter, provided a CO_2 smothering installation; that was in about the year 1840.

Spontaneous ignition fires also occur in certain kernel and seed cargoes of an oily nature when in the bagged condition and particularly when loaded wet. With regard to spontaneous ignition fires generally, however, the author is becoming increasingly suspicious that this scientific sounding phrase is all too frequently used as a convenient nobody-to-blame excuse when it comes to assigning probable causes in fires whose origin is otherwise a mystery and may well have been the humble cigarette.

Recent experiments at the Fire Research Station at Boreham Wood suggest that a glowing cigarette stub can be buried under three feet of sawdust and that smouldering will not reach the surface for about twelve days, during most of which time it will remain incapable of detection externally. It does therefore seem that, given a type of cargo capable of smouldering under restricted air conditions and buried under a depth many times that of the experiment, it may be quite wrong to assume spontaneous ignition as a cause merely because the hatches have been battened down for a prolonged period before the fire is detected. Unfortunately, the only lesson to be learned from this evidence is to try and enforce the "no smoking" rule during loading, which is not easy, yet the precautions taken when loading petroleum and explosives show that it can be done. Continuous surveillance at the square of the hatch is obviously not sufficient and yet patrol of all spaces where surreptitious smoking might occur would seem commercially impracticable as also would a total prohibition enforced by a gateway or gangway search as with explosive cargo. It seems therefore that having taken all reasonable precautions the smoking risk must continue to be accepted for ordinary cargoes but if a thorough patrol of all spaces to which stevedores and crew have had access was undertaken as a regular routine half-an-hour or an hour after work ceased, many fires would be prevented.

DETECTION AND EXTINCTION OF CARGO AND CARGO SPACE FIRES

Detection of such fires is well catered for by the well known combined detection and CO_2 smothering system, particularly when an audible alarm is incorporated, but the use of perforated thermometer and sounding pipes to detect any undue rise of temperature or the presence of smoke or smell and even the use of the simple smelling plugs in steam smother-

* Engineer Surveyor in Chief, Ministry of Transport and Civil Aviation.

ing distribution valve boxes can be effective. It is useful to remember that a seaman's sense of smell is keen and remains on watch however much he may be preoccupied with other matters, so the wheelhouse smoke detector discharge should not be diverted to atmosphere unless the cargo is particularly rank and even then it should be sniffed at regular intervals.

Regarding extinction, the need for prompt battening down is well understood but it is important that ships' officers should know what openings serve the suspected space since ventilators may serve adjacent holds and bulkheads may be pierced by trunking. If the fire is deep seated or extensive it is usually advisable to keep it under control by the smothering medium and not to open up until port facilities are available.

The vital importance of battening down will be realized when it is remembered that if one hundred per cent gastight closure can be maintained, any ordinary cargo fire will put itself out unaided merely by consumption of all the available oxygen, though at the expense of destruction of cargo and possible structural damage, both of which will be reduced or avoided by injecting a smothering medium.

Where the close proximity of the fire shows up in heated decks or bulkheads, the electric drill provided as part of the fire fighting equipment may be used to make a ring of holes to cut out an opening about 2-in. diameter for the insertion of a hose nozzle.

The present choice of recognized extinguishing mediums for cargo holds in British ships is surprisingly narrow, comprising, as it does, steam and carbon dioxide only but the choice shows signs of being extended since the m.v. *Oti* went into commission in May 1956 with the first inert gas generator to be installed in a British ship.

Steam has had a long and successful record but it belongs essentially to the days of the cylindrical marine or Scotch boiler with its ample capacity and its ability to use salt feed if necessary. With watertube boilers the steam supply may be limited by the capacity of the evaporators if risk of damage to the boilers by salt feed is to be avoided. Undoubtedly steam has saved many ships from becoming total losses at sea in the past, not necessarily by completely extinguishing the fire in the cargo but by holding it in check for days on end until port was reached. Losses from condensation of the steam would appear to be partly offset by the useful fire retarding effect of wetting the cargo but the resultant overall damage from such wetting is of course one of the main disadvantages of steam.

CO_2 gas on the other hand has the advantage of not damaging the cargo at all, while it is always available for immediate use and can be applied very quickly. Once the charge is wholly released it is of course necessary to send the bottles ashore for refilling and these may amount to some forty to sixty in a ship of 6,000 to 10,000 gross tons. It is now possible to ascertain whether a bottle has suffered accidental leakage and loss of contents by a type of isotope liquid level indicator which saves the labour of removing each bottle from its rack for weighing.

Regarding inert gas it has always been a tempting proposition to make use of the funnel gases going to waste in large volumes but the practical difficulties have so far proved insurmountable for general use, the excess air always present to a greater or lesser extent being the main drawback. However, the inert gas generator referred to in the m.v. *Oti* is in fact a variation of this basic idea, the equivalent of the funnel in this case carrying only the products of combustion from a carefully controlled oil fuel burner so that the oxygen content is at a safe minimum, leaving only nitrogen and CO_2. The gas is washed and indications are that there is no taint. The apparatus is self-contained, with its own Diesel engine driving the pump and fan, and was first used ashore in both portable and fixed models for purging tanks which had contained inflammable gas and which had to be made safe from explosion hazard. Distribution pipes are required for the cargo spaces and these are of necessity of larger diameter than with steam or CO_2 because of the low fan discharge pressure.

The attractive feature of inert gas produced thus is that it shares with steam the advantage of being almost unlimited in amount and provided pipe sizes are not unduly restricted it can reduce the oxygen content of the hold at a satisfactory rate. The rate of production of the inert gas is too slow, however, to deal with oil fires. A smoke detection system can be incorporated in the installation by making partial use of the gas distribution pipes.

ACCOMMODATION FIRES IN CARGO SHIPS

In this field the number of small fires predominates and large numbers go unreported. Undoubtedly smoking is the main cause but at sea the spaces are continuously occupied by some part of the crew which usually results in early detection and prompt extinction, hence no report. It is rarely that damage in a cargo ship at sea extends beyond one or two rooms but in port the risk is much greater and depends largely on the frequency and efficiency of the patrol arrangements.

Regarding causes of fires in accommodation, only smoking has so far been mentioned and it may be wondered why that old friend, the electrical fault, has not been given pride of place. Fires do occur from this cause but the author feels strongly that this satisfying caption is another of those convenient no-one-to-blame explanations for mystery fires. In the bad old days genuine electric cable fires were no doubt frequent, but with better installations and insulation and a tightening-up of safety requirements the present position as shown by the tables is much more satisfactory. It will be noted that misuse of electric appliances is listed separately. If a cargo cluster is left switched on while resting on an inflammable cargo in a closed hold it is hardly fair to call it an electrical fault; a ship's officer could find a much more expressive description.

Paint having a nitro-cellulose base is not allowed in the accommodation or service spaces in any ship, while accumulations of oil base paints are also undesirable. Fire-resistant paints are available. Any owner anxious to ensure a minimum risk of the spread of accommodation fires can of course adopt any of the methods used in the passenger ships, of which the use of flame-resistant materials and finishes which do not need painting appear to be most attractive. This is being done by several companies, particularly in the tanker fleets.

The practice of having a small grille or louvre, as generally required by crew space regulations, in some part of the cabin door or passage bulkhead by which telltale smoke or smell can escape is a simple and obvious means of detection and might occasionally save the lives of some of those referred to as smoking-in-bed-suicides. The use and placing of such an opening will depend upon the ventilation arrangements.

EXTINCTION OF FIRES IN ACCOMMODATION IN CARGO SHIPS

The first rule in such fires is to use the nearest appliance and to raise the alarm and meanwhile not to leave open any door which will allow the access of fresh air. Pending the arrival of breathing apparatus and hose, use can be made of the fact that smoke is usually densest in the upper part of the space.

The two-gallon extinguisher discharging water has stood the test of time for this purpose, though other mediums and methods such as CO_2 and dry powder are constantly being proclaimed as having various advantages. In passing, it is surprising how often one sees on board ship the familiar liquid type extinguisher which has dribbled a part of its contents down its otherwise decorative exterior due to a choked breathing hole. The toxic fumes from carbon tetrachloride extinguishers both before and after a fire can be deadly in a confined space and such extinguishers are only allowed in small capacities and for special purposes such as switchboard fires. Methyl bromide extinguishers are not permitted on British ships.

Accommodation fires in passenger ships have not been dealt with in this paper except where mentioned in the tables as the subject is referred to in another paper in this symposium.

There seems little hope of extinguishers for shipboard use ever being standardized in their method of operation, however desirable this may be, but with frequently changing crews there are many extinguishers which might with advantage be more clearly marked with big, bold instruction lettering instead of being used as advertisements for their makers or vendors.

MACHINERY SPACE FIRES

Basically, a machinery space built entirely of steel should be immune from fire if it were not for the presence of oil and the fire hazard only occurs when the oil gets into the wrong place through carelessness or accident. It cannot be repeated too often or too strongly that cleanliness is the first essential in any machinery space. It is always a joy to see clean, well lighted tank tops and bilges in any ship. The use of inflammable paint should be avoided as far as possible.

The records show, however, that there is no room for complacency in regard to the fire risk in the machinery space of the modern steam and motor ship. Apart from coal bunker fires, which in any case seldom got out of hand, the coal fired steamship was largely immune from serious machinery space fires. With the advent of oil fuel forty years ago, the picture changed radically. Not only were there quantities of fuel which, once ignited, blazed up with fearful speed and produced volumes of dense black smoke, but fuel was carried about the machinery space in pipes not all of which were so placed that leakage could not become ignited. Furthermore, the oil was heated and put under pressure in the vicinity of a permanent source of ignition, the boiler front. Now oil pressures are more than double what they were fifteen years ago and this boiler front risk is still the most dangerous today. Cleanliness and easy access to and prompt use of local and remote control valves is the first essential if a major outbreak is to be avoided.

When the oil engine was introduced there was an obvious reduction in the fire risk since there was no open flame to provide ignition; moreover, the heated surfaces, namely, the exhaust pipes, were usually well above any pipes conveying oil. Unfortunately, however, the motor ship usually has one or more auxiliary boilers and there is ample proof that this is a source of danger. It would indeed seem that fires from such auxiliary boilers are more frequent than from main boilers for the reason that they are left for longer periods without attention.

If all auxiliary boilers in motor ships were placed in gas-tight casings instead of being in the open engine room and if fans were stopped and smothering gas were injected automatically or by external control on the outbreak of fire, this major risk would be removed.

Regarding the main and auxiliary engines in motor ships, provided oil pipes and tanks are placed where leakage cannot

TABLE I. CAUSES OF FIRES IN BRITISH SHIPS OF OVER 100 GROSS TONS FROM JANUARY 1951 TO JUNE 1956

	Cargo and cargo space		Accommodation and stores		Machinery space		Coal cargoes		Coal bunkers		Tanker cargo and cargo space		
Cause	At sea	In port	At sea	In port	At sea	In port	At sea	In port	At sea	In port	At sea	In port	Totals
Spontaneous ignition	31	39	–	–	–	–	13	4	15	18	–	–	120
Smoking proved or suspected	7	38	21	50	1	2	–	–	–	–	1	–	120
Welding and burning	–	19	–	24	–	24	–	–	–	–	–	3	70
Heated surfaces, pipes, bulkheads, uptakes, hot rivets	–	5	3	3	15	4	–	–	8	4	–	–	42
Oil fuel at boilers	–	–	–	–	11	26	–	–	–	–	–	–	37
Petrol	–	–	–	2	–	1	–	–	–	–	–	–	3
Oil overflow and spray leakage on to hot surfaces	–	–	–	–	14	8	–	–	–	–	–	–	22
Electrical fault	–	1	5	14	2	3	–	–	–	–	1	–	26
Misuse of electrical apparatus	3	8	4	7	–	–	–	–	1	–	–	1	24
Sparks from funnel, including galley funnel	1	2	4	5	2	–	–	–	–	–	–	–	14
Friction	5	5	–	–	–	–	–	–	–	–	–	–	10
Sabotage	–	1	1	7	2	–	–	–	–	–	–	–	11
Galley	–	–	1	16	–	–	–	–	–	–	–	–	17
In exhaust pipe silencer, scavenge trunk	–	–	–	–	7	4	–	–	–	–	–	–	11
Boiler uptakes	–	–	–	–	7	5	–	–	–	–	–	–	12
Stoves and naked lights	–	1	2	8	2	4	–	–	–	–	–	–	17
Miscellaneous	5	4	2	3	1	5	–	–	–	–	–	–	20
Unknown	18	43	7	23	7	8	6	1	–	–	–	8	121
	70	166	50	162	71	94	19	5	24	22	2	12	
	236		212		165		24		46		14		697

drip or spray on the exhaust pipes or on any dynamo or motor, the risk is small.

It is important to note that the word oil has been used deliberately to include lubricating oil as well as boiler fuel oil and Diesel oil, since these are all hydrocarbons. The ignition of these oils may be brought about by flushing a small quantity over a metal surface heated to a temperature as low as 550 deg. F. notwithstanding various ignition tables which give much higher spontaneous ignition temperatures for minute quantities. These tables are of interest, however, in showing that flash point bears little relation to spontaneous ignition temperature, which is much the same for lubricating oil as for fuel oils. For instance, the flash point of lubricating oil is about 150 deg. F. above that of fuel oil, while its spontaneous ignition temperature may actually be a few degrees below that of fuel oil.

Internal fires occur in heavy oil engines from accumulation of lubricating oil and dust in the scavenge trunk as a result of too infrequent cleaning. Such fires are not usually dangerous if external paint or oil are not present and, if CO_2, foam or sprayed water is available.

Crankcase explosions with the discharge of flame into the engine room, unless a flame trap is fitted, would at first sight appear to be the surest way of starting a major engine room fire. While not attempting to belittle the risk, it is nevertheless a fact that records of thirty-five such explosions in British ships show no major fire from this cause. The explanation appears to be that the period of flame is so short that only very light material such as clothing, cotton waste or some oil already near firing point and giving off readily ignitible gas will ignite. In recorded cases minor fires from this cause have been dealt with by two-gallon extinguishers. The deadly damage such flame can inflict on personnel is a much more serious reason why such explosions should be prevented at all costs.

In turbine engine rooms steam temperatures have now reached the spontaneous ignition temperature of lubricating oil and, if there are any exposed surfaces such as valve covers or flanges, oil leakage can start a fire. Fires from oil soaked lagging are not infrequent but rarely get out of hand because of the limited supply of fuel.

TABLE II. SERIOUS OR FATAL FIRES IN BRITISH SHIPS OF OVER 100 GROSS TONS FROM JANUARY 1951 TO JUNE 1956

Cause	Cargo and cargo space		Accommodation and stores		Machinery space		Coal cargoes		Coal bunkers		Tanker cargo and cargo space		Totals	Total deaths
	At sea	In port	At sea	In port	At sea	In port	At sea	In port	At sea	In port	At sea	In port		
Spontaneous ignition	2	1	–	–	–	–	2	–	2	1(1)	–	–	8	(1)
Smoking proved or suspected	1	2	2(2)	4(4)	–	–	–	–	–	–	–	–	9	(6)
Welding and burning	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Heated surfaces, pipes, bulkheads, uptakes, hot rivets	–	3	–	–	–	–	–	–	–	–	–	–	3	–
Oil fuel at boilers	–	–	–	–	5	–	–	–	–	–	–	–	5	–
Petrol	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oil overflow and spray leakage on to hot surfaces	–	–	–	–	4	4	–	–	–	–	–	–	8	–
Electrical fault	–	1	–	–	–	–	–	–	–	–	–	–	1	–
Misuse of electrical apparatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sparks from funnel, including galley funnel	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Friction	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sabotage	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Galley	–	–	–	–	–	–	–	–	–	–	–	–	–	–
In exhaust pipe silencer, scavenge trunk	–	–	–	–	1	–	–	–	–	–	–	–	1	–
Boiler uptakes	–	–	–	–	2	1	–	–	–	–	–	–	3	–
Stoves and naked lights	–	–	–	2(1)	–	–	–	–	–	–	–	–	2	(1)
Miscellaneous	–	1	–	–	1	–	–	–	–	–	–	–	2	–
Unknown	1	3(1)	1	1	5(5)	2	–	–	–	–	–	2(4)	15	(10)
	4	11	3	7	18	7	2	–	2	1	–	2		
Total fires, all causes	15		10		25		2		3		2		57	
Total deaths	–	(1)	(2)	(5)	(5)	–	–	–	–	(1)	–	(4)		(18)

Note: Deaths shown in brackets.

If oil tanks and their connexions are so placed as to lie in the path of the flames the old fashioned round gauge glass will immediately supply fresh fuel to the fire. Self-closing cocks defeat the purpose of the gauge glass as a permanent visual indicator but fortunately contents gauges which do not pierce the tank are available. Trays fitted below tanks with an air space between form a valuable shield to prevent the tank contents boiling up and adding to the fire.

EXTINCTION OF MACHINERY SPACE FIRES

In how many ships does fire drill envisage a machinery space fire and in how many ships does every member of the staff know the whereabouts and use of the whole of the fire prevention and fire fighting equipment? 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, though of recent years there is evidence of improvement.

Giving the alarm and shutting off the oil supply are so obviously among the first actions to be taken that it is surprising how often this is left too late. If the person discovering the fire has the least doubt as to his ability to extinguish the fire with a single extinguisher and cannot attract attention by a shouted alarm then he should immediately make use of whatever alarm signal is provided or go in person to the bridge or fire control station.

Two-gallon foam extinguishers followed by ten or thirty-gallon extinguishers can hardly be bettered for initial attack, though CO_2 and dry powder extinguishers have advantages in certain cases. The visible jet of foam lasting not less than sixty seconds for the two-gallon size and not less than ninety and one hundred seconds for the ten and thirty-gallon sizes respectively can be used to follow the flame round seatings and suchlike obstructions which are not always a feature of the trays used at fire extinguisher demonstrations. Moreover, re-ignition of the oil is unlikely to occur under a foam blanket.

While the initial attack is proceeding, the fire party in accordance with the prearranged fire drill should be mustering the spray nozzle fire hoses and breathing apparatus, stopping fans, closing openings, starting the emergency fire pump and preparing to discharge the main installation of foam, smothering gas, steam or water spray.

In order to provide some means of supplementing the two, ten and thirty-gallon extinguishers for local attack directed at the seat of the fire, and to meet the criticism that foam on the tank top is wasted in the case of a fire at a higher level, arrangements are provided to draw on the main foam supply for application by hose and in this case the amount available is limited only by the capacity of the main supply. This obviously cannot be done with CO_2 or the operator of this "at will" distribution would gas himself but in such cases it is quite safe to provide for two to four bottles each containing 80lb. of CO_2 to be discharged directly at the fire before evacuating the space and discharging the main supply. Steam does not lend itself to the "at will" method of attack. The question of the best type of fixed installation for dealing with a major fire in a machinery space is very far from being finally settled and with such a variety of conflicting considerations and opinions this is not surprising. For a tank top foam installation it can be claimed that since that is where any escaping oil must eventually lodge it is the right place to lay the 6-in. blanket. Critics point out that the flame, however, may continue at a higher level at the point of escape. If by any chance the escape of oil is from a source which cannot be shut off, the blazing stream will thus continue and may involve other sources of oil at a higher level, such as storage and service tanks, or may spread to accommodation or holds through bulkheads which in cargo ships may not be fire resisting. Foam has the advantage that it can be applied quickly without waiting for closing down to be completed and without evacuation of personnel. If the foam fails there is still the emergency pump supplying water through hoses fitted with spray nozzles by which the fire may be attacked or at least prevented from spreading beyond the space. In certain types of foam installation, a spare charge or charges can be carried conveniently so that the ship is never unprotected.

Steam is allowed as the smothering medium in the boiler rooms of cargo ships, and with Scotch boilers, even after shutting off the fuel, an ample supply may be depended on. The same cannot be said of watertube boilers. When steam is used, closing down and evacuation are necessary but are not quite so urgent as with CO_2. Again, the emergency pump is available as a second line of defence. Once the fire is extinguished and provided the boilers are undamaged, the ship remains protected against further fires.

CO_2 has the advantage of immediate availability and, provided closing down has been promptly and effectively done, it probably offers the best chance of complete extinction where-

TABLE III. TOTAL OR CONSTRUCTIVE TOTAL LOSS OF BRITISH SHIPS OF OVER 100 GROSS TONS FROM JANUARY 1951 TO JUNE 1956

Name of ship	Type of ship	Gross tons	Cause of fire	Loss of life	Remarks
M.V. *Donna Betta*	Yacht (wood)	196	Arson suspected	–	Carried cargo. Machinery space fire; electrical fault blamed. Ship grounded and burned out.
S.S. *Alpera*	F.G. cargo	1,406	Settling tank overflowed	–	Machinery space fire. Ship burned out.
M.V. *Cape Coast*	F.G. cargo	1,722	Smoking	–	Ship was leaving the Congo with cargo of sunflower seed and oil cake.
M.V. *Menestheus*	F.G. cargo	7,797	Explosion from auxiliary generator manifold	–	Machinery space fire fed by escaping oil.
S.S. *Marvia* (Malta)	F.G. cargo	523	Sling of cargo insecure	–	Drum of carbon bisulphide dropped on hatch. Ship burned and sank in port.
M.V. *Empire Windrush*	Troopship	14,414	Unknown	4	Four engineers were trapped in engine room. Sank at sea.
S.S. *Herriesburn*	F.G. cargo	1,699	Unknown	–	Overheated coal cargo suspected. Amidship accommodation destroyed. Forward holds on fire. Ship sank.
M.V. *Wilhelmina* (Bermuda)	Passenger ferry (composite)	Estimated over 100	Unknown	1	Fire in engine room. Vessel beached.
S.S. *Empress of Canada*	Passenger	20,325	Unknown	–	Sank in dock.

ever the fire may be situated. Stopping the propelling machinery and shutting off the boiler oil burners is necessary and this and evacuation of personnel can proceed concurrently with the closing down of openings. The CO_2 can then be injected very rapidly by the gang release system. The emergency pump is capable of dealing with any incipient fire in adjacent compartments and for cooling down at the seat of the main fire to prevent re-ignition when ventilation is restored. If the ship has a separate CO_2 supply for cargo holds which can be made available for the machinery space, she remains protected after the fire.

It is noted that the 1948 International Convention regulations allow for the use of a high pressure water spray in machinery spaces. The difficulty of providing pumping capacity or storage under pressure has in the past prevented the adoption of this method. The term high pressure might lead one to suppose that the higher the pressure and the finer the spray the more efficient the application of water would become. Again, research has come to our aid and found that a satisfactory drop size for dealing with oil fires can be obtained at the quite moderate pressure of about 45lb. per sq. in. The theory appears to be that a finer drop is likely to be carried up by convection currents in way of the fire and never get down to its real job of cooling the oil at the surface to prevent the continued evolution of ignitible gas. The water spray system which has recently undergone prototype tests in ships has some very attractive features, the first and most obvious being the unlimited supply of sea water. Give any shore Fire Service Officer an ocean of clean sea water within a hose length of a major fire and suggest that he deals with it without using water and his reactions are likely to be explosive and yet a minority of ships are so fitted that if their machinery space is vacated because of fire they would be left with no means of making use of water at all. The second advantage is that there is no need to evacuate the space before applying the spray and indeed it would no doubt be very welcome to the first aid fire party. Tests have shown that an application of spray for something under three minutes can extinguish a large oil fire so that there is no question of stability being endangered and further drenchings can be applied if found necessary. Smoke is likely to be reduced and the space maintained in habitable condition. The disadvantages are the size of pump which must be wholly allocated to this service, while both the pump and its source of power must obviously be outside the space to be protected; also, electrical machinery requires protection.

An attractive variation of the spray system which can be adopted on the majority of ships at negligible cost is to have a few widely spaced holes in the sides of the machinery space casing with movable covers so that in the event of a major fire water can be sprayed in at suitable positions by means of the emergency pump, hose and spray nozzles, for which purpose it is necessary to carry spray nozzles on deck as well as in the engine room. The heat or flames will convert much of this spray into steam and provide a smothering blanket which, together with the cooling effect of the heavier spray, may prove successful. In an oil fire there is of course no time to start drilling holes for this purpose even if power is available, the electric drill provided as part of the statutory equipment being intended for cargo space fires.

CLOSING OF OPENINGS

This is the part of the fire fighting organization which is most liable to fail and yet such failure may have very grave consequences, particularly in machinery spaces and accommodation. Butterfly valves or flaps are sometimes fitted in ventilators and trunks but they are difficult to maintain in gastight condition. Attention was recently drawn to an attractive type of ventilator valve which seated on an annular gastight joint and which could be lifted and turned through ninety degrees to give maximum opening in one simple movement of the external handle. In any case, with the ordinary flap valves, the openings should have canvas covers lashed over them, supplemented by wooden plugs where these are provided under the load line rules. An air escape and observation opening left at a corner of the hatch when injecting gas or steam has been found useful.

In machinery space fires the first aid party attacking the fire should not delay operations to close openings but if the alarm has been raised as it should the officer in charge should put the closing drill in operation immediately. The fierce flame of an oil fire will immediately create very powerful convection currents and produce a blast furnace effect if not checked. Inlet and outlet openings are almost equally important. For fire fighting purposes, including observation, attack and escape, it is necessary to have access to the machinery space at bottom platform level since the dense smoke of an oil fire usually makes the upper spaces untenable. Fortunately, the majority of dry cargo and passenger ships have their machinery amidships and the shaft tunnel provides the ideal approach to or escape from a machinery space fire, offering as it does a long cool approach with an entrance or exit on deck as far removed as possible from the seat of the fire. There has been ample evidence that access by way of the tunnel has been used successfully on several occasions recently. The provision of a light hinged steel door operable from both sides in addition to any watertight door has many advantages, since the latter is too slow for fire fighting purposes though it can be closed by remote control if the space is finally evacuated.

In accommodation spaces there are usually plenty of doors between spaces to retard the spread of fire and in passenger ships special self-closing fire-resistant doors are required at specified intervals but in any ship it is necessary to educate the crew not to leave doors open behind them when a fire occurs.

BREATHING APPARATUS

This is a controversial subject and at the outset it should be quite clear as to whether such apparatus is being considered

TABLE IV. NUMBERS OF FIRES IN DIFFERENT CARGOES IN BRITISH SHIPS OF OVER 100 GROSS TONS FROM JANUARY 1951 TO JUNE 1956

Cargo	At sea		In port		Totals
	F.G. ships	Coasters	F.G. ships	Coasters	
Cotton, cotton waste and seed	4	2	18	2	26
General	14	–	8	3	25
Jute	–	–	19	–	19
Palm kernels	3	–	14	–	17
Wool and wool flock	3	–	7	–	10
Chemicals, solid, various	–	–	6	3	9
Seed expellers	5	–	4	–	9
Fibres (vegetable)	1	1	5	–	7
Rags, bags and canvas	2	–	3	–	5
Meat	–	–	4	–	4
Grain	–	–	3	1	4
Sulphur	–	–	4	–	4
Paper and tissue	–	–	1	2	3
Peat	–	–	–	3	3
Sodium hyposulphate	2	–	1	–	3
Esparto grass	2	–	–	–	2
Oil cake	2	–	–	–	2
Activated carbon	2	–	–	–	2
Sugar	–	–	2	–	2
Rayon	–	–	1	–	1
Timber	–	–	–	1	1
Wood pulp	–	–	1	–	1
Nitric acid	–	–	1	–	1
Carbon bisulphide	–	–	1	–	1
Film scrap	1	–	–	–	1
Iron oxide	1	–	–	–	1
Tobacco	–	–	1	–	1
Tapioca	–	–	–	1	1
Flour	1	–	–	–	1
Fish manure	–	–	1	–	1
	43	3	105	16	167

for fire fighting or for rescue or even for tank cleaning operations. The air bellows or blower type with helmet or mask has given useful service for thirty years at sea and it has two very important advantages, namely non-expendability and simplicity. Provided the helmet cape is well tucked under the jacket or the mask is a good fit so that the air pressure keeps smoke from entering, and provided the bellows operator sees that he is supplying clean air, this type of apparatus is most useful for tackling a prolonged fire with the fire fighters working in relays. On the other hand, the self-contained type is of necessity expendable but has the advantage of greater mobility; it is, therefore, suitable for short term use and especially for rescue work. The compressed air type requires some practice in use but is acceptable in any ship. The oxygen type requires rather more training, however, and is not at present accepted as statutory equipment. Although statutory requirements only cover the supply of breathing apparatus for fire fighting for which the air hose type is necessary, a recent Ministry recommendation in Notice M.388 allows additional apparatus to be of the self-contained compressed air type so that the apparatus can thus be chosen to suit the particular emergency, whether it be fire or rescue.

EXPLOSIONS FROM COAL GAS

In the last five-and-a-half years there have been thirteen such explosions at sea resulting in the loss of one killed and seventeen injured. In only one case did fire result.

These accidents are preventable and prevention falls under two main headings: (a) prevention of escape of gas from the cargo space to a compartment where there may be a source of ignition and (b) prevention of an accumulation of gas by ventilation. Regarding (a), the source of leakage is nearly always small and unsuspected, such as telegraph cable casings or holes for electric cable, allowing gas to percolate into some accommodation space where smoking is permitted. Scrupulous care on the part of builders, repairers and their many sub-contractors is the only answer to this hazard. Regarding (b), there would be little risk if the ventilation provided by the builder could be used under all conditions at sea. Unfortunately, bad weather usually results in most if not all the ventilators having to be plugged and accumulation of gas becomes almost inevitable. It this is not got rid of before hatches are opened for discharging cargo, there is a period of danger when some unsuspecting person may provide the ignition. The modern steel hatch is likely to be more gastight and can be opened up much quicker than the wood and tarpaulin covering and pre-ventilation is therefore even more necessary. Three of the explosions mentioned above were in ships fitted with steel hatch covers. There appears to be a need for a type of ventilator which can prevent the ingress of sea water while retaining its main function of allowing gas to escape.

THE AVOIDANCE OF CAPSIZING IN FIGHTING MAJOR FIRES

This is a form of disaster upon disaster which has become all too familiar in recent years and salvage operations have consequently been unduly costly. It is, however, a problem which applies to the ship in port in a more acute form than to the ship at sea for the reason that the amount of water which can be pumped into a ship by a dozen or more fire engines and fire floats is so many times greater than the amount which could be delivered by the ship's fire pumps alone. The stability problems involved and a suggested method of approach are described in detail in a paper* read before the Institution of Naval Architects by H. E. Steel in March of this year. It is of course the building up of free surface water, particularly at 'tween deck level, which is the immediate danger and the solution of the problem is far from simple. The first and obvious solution is to keep the applied water to a minimum by the use of spray nozzles and by directing the spray only where it will have some chance of being effective. The second solution, which is also obvious but is less easy of attainment, is improved drainage facilities. In the cargo ship the usual grid over the scupper is likely to become choked very soon and unless the owner is willing to fit a more elaborate design of grid and scupper for such emergencies there is little that can be done in this direction. In the passenger ship the difficulties are greater because in addition to grid trouble the cabin partitions do not allow of any intercommunication and fore and aft drainage is thus prevented, while a separate scupper for each cabin is impracticable. A recent development is for the shore based fire fighters to provide equipment for removing the water they have pumped into the ship by means of a portable ejector worked by pressure from the shore hose. In favourable circumstances a well designed ejector might be the means of preventing capsizing while allowing fire fighting to continue. Cutting holes externally in the ship's side when the emergency occurs is a drastic remedy, to be used with extreme caution, while any decision to scuttle the ship will depend on the depth of water under the keel and the slope of the dock or harbour bottom. Thus, if the depth is small and the bottom flat the ship would settle upright and reduce damage and salvage costs very considerably. If the ship can be towed into shallow water, so much the better.

* Steel, H. E. 1956. "The Practical Approach to Stability of Ships". Trans.I.N.A., Vol. 98.

COMMENTS ON THE FUTURE TREND

Commentators on ship fires are prone to quote all the disastrous fires which have occurred in the past without reference to date or nationality and to give scant credit to all the improvements which have taken place in the last five years and it is with this in view that the findings in this paper are confined to fires occurring in British ships since these improvements became general. It is therefore possibly somewhat premature to forecast further improvements. The following notes are based strictly on defects and deficiencies shown up by recent fires.

SHIPS IN PORT

The position regarding fires in ships in port can be summed up quite briefly by saying that if the recommendations of the 1950 Working Party Report on Fire Prevention and Fire Fighting in Ships in Port issued by the Ministry of Transport had been followed, the great majority of these fires would never have occurred and it is significant that after the *Empress of Canada* fire in 1950 very little could be found to add to those recommendations except that they should be followed instead of being ignored.

SHIPS AT SEA

Further improvements at sea would appear to lie in the folllowing directions:

- Extension of fire mindedness and training in fire fighting, from which benefits are already apparent.
- Provision of automatic fire detection in holds, including audible alarm.
- Improvements in methods of sealing openings efficiently and expeditiously, particularly in machinery spaces.
- Maintenance of pressure on fire main to ensure instant availability.
- Keeping up the drive for cleanliness in machinery spaces with the emphasis on prevention of oil leakage.
- Insulating all hot surfaces to prevent ignition by accidental oil leakage.
- Placing oil tanks of all descriptions where they cannot become involved in flame from a major fire sweeping up the inside of the machinery casings.
- Making machinery casings fire resistant.