HYGIENE.

By Fleet Surgeon R. C. MUNDAY, R.N.

JUST as the fighting service of the navy was found, at the outbreak of war, prepared at all points for any emergency, so also the medical service of the navy stood equipped with every weapon that modern sanitary science could suggest. In August, 1914, many eminent combatant naval officers were of opinion that the numerous and far-reaching precautions for safeguarding and fostering the health of the personnel would to a great extent have to be abandoned in the face of the pressing exigencies of modern warfare. It was also generally thought that the war would probably be of short duration, and that many conditions of life which, if long continued, would be detrimental to health, could and indeed must be endured for a few months. The Director-General of the Naval Medical Department, however, has from the outset always maintained that the objects to be kept constantly in view are to keep as many officers and men as possible in the highest state of fighting efficiency, and to reduce the loss of service from sickness to a minimum. It was evident also that the means to this end were constant supervision of the daily life of the personnel and the continuous adoption in practice of measures born of modern research. As a result of this doctrine, the war, instead of producing a reduction or relaxation of the requirements of modern sanitation, brought with it a great speeding up of hygienic vigilance, together with progressive improvement in the appliances and apparatus employed in preventive medicine throughout the naval service, not only afloat but also in our many shore establishments. Combatant officers and local administrators who were at first sceptical or even strongly opposed to activity in such directions have come to see the military advantages accruing therefrom, and now demand the maintenance of a high standard of hygiene. That success, beyond anything the most optimistic prophet could have foretold, has attended the efforts made by the Naval Medical Service is evident from the extraordinarily small loss of service from sickness in the navy, in the dockyards, and in the Admiralty munition factories; moreover, the well established fighting efficiency of our sailors and aviators points in the same direction.

Ventilation.

The improvements in our warships since hostilities commenced are perhaps more pronounced in the matter of ventilation than in any other branch of hygiene. These improvements are the outcome of recommendations made by a committee appointed by the Admiralty at the end of 1912 to investigate and report on the best methods of ventilating modern warships. The Admiralty were moved to this step by certain observations recorded at a series of conferences of naval and civilian medical men summoned in 1910 to consider and report on the causes and effects of tuberculosis in the navy.

In March, 1913, a First Interim Report was submitted by the Committee to the Admiralty, making certain urgent recommendations of a constructional nature; and as a result of these representations a definite minimum standard—200 cub. ft.—of individual cubic space for sleeping places was laid down, and a uniform minimum fan supply of 3,000 cub. ft. of air per hour per man was arranged for all sleeping and all ordinary working and living spaces. The position of various ventilators on the weather deck was so arranged as to ensure a continuous supply of pure air under all conditions of weather and sea. The undesirable position also of certain alternative intakes between decks was abolished and methods of improvement in this respect were inaugurated. The Committee considered that a powerful exhaust effect from the engine room and stokehold ventilation was available for use on the mess decks when required; but as a general rule they strongly recommended, and the Admiralty adopted, the plenum system combined with natural exhaust for living spaces, and the fan exhaust system with natural supply for spaces in which are generated disagreeable odours, great heat, water vapour, or deleterious gases; but it was specifically stated that no fan supply should be fitted for the ventilation of such places. Silent-running fans, means for avoidance of draughts, arrangements for accessibility of the interior of air trunks for cleaning purposes, and the fine adjustment

of, and protection from unauthorized tampering with, air-warming appliances are now fitted in all new ships. Formerly improvement in the ventilation and drainage of bathrooms was urgently needed, and at the suggestion of the Committee special innovations were introduced by which the atmosphere in these places was rendered purer and at the same time prevented from pervading the living spaces. Lastly, the inadequate electric lighting of mid-shipmen's studies and of departmental offices was corrected, a 3 ft. candle illumination on the desks being so arranged that the light passes over the left shoulder of the person reading or writing; now also offices in which persons are working most of the day are placed where natural light and ventilation are available. Not only did the Admiralty order the recommendations to be embodied in the designs of all new ships, but they also gave instructions that so far as was feasible completed ships should be brought into line with the Committee's pronouncements, and during the war, as the older ships have come into dockyard hands for a refit, their ventilation and sanitation has been brought up to date.

In April, 1913, a Second Interim Report was published, dealing chiefly with administrative matters, and in accordance with the Committee's suggestions a senior medical officer was appointed as an additional member of the staff of the Medical Director-General to assist the Director of Naval Construction in the consideration of all plans and details of fittings in connexion with ventilation and hygiene of ships building, all such plans being referred to the Medical Director-General's department for that purpose before final approval was given. This medical officer was also placed at the disposal of the Director of Naval Equipment in the event of his requiring expert advice on any point of naval hygiene, and the former now inspects the hygienic arrangements, including ventilation, in ships building as they approach completion, so as to avoid as far as possible any necessary alterations when the ships are completed; he also co-operates with the above departments in dealing with proposed alterations and improvements in the ventilation and sanitation of ships already built.

Further, there is on board every ship one commissioned officer responsible to the captain for the general supervision and the best use of the means available for the ventilation of the ship; and whether, in every case, the senior medical officer be actually employed on this duty or not he is at least always in close touch with the officer detailed for it, and is now recognized as the official expert on matters of ventilation and hygiene generally. Moreover, every ship now has a well-organized ventilation party for the management of the ventilation appliances under the orders of the ventilation officer. The medical officers also give lectures on board ship to officers and men on elementary hygiene, with especial reference to ventilation; assistant constructors going through a course at Greenwich College attend the lectures on naval hygiene given at the medical school there, and medical officers under instruction at Greenwich are taught the construction of fans, how to read plans of ventilation, and the considerations governing the volume and velocity of air passing through trunks, ducts, etc.

As affording a good index of the efficiency of the means of ventilation, regular observations of wet and dry bulb temperatures in living and working spaces are made by medical officers afloat, and samples of air are taken in compartments where the ventilation seems unsatisfactory. These samples are sent to Greenwich College for analysis and report in duplicate, one copy being forwarded to the ship and the other to the Medical Department for the information of the Director-General, and to enable him to keep in touch with the requirements of ship ventilation. Every ship also now submits a quarterly report, signed by the captain, showing what means of ventilation and warming have been in use, the extent of the supervision exercised, records of wet and dry bulb temperatures taken in living spaces, and results of analyses of air, together with any recommendations for improvement.

The Final Report of the Ventilation Committee was issued in March, 1914, and contained *inter alia* a proposal for a new system of trunking, devised, after a long series of experiments at Portsmouth Dockyard, to overcome the disadvantages of previous systems by which intolerable draughts were produced and air and warmth were distributed in a most uneven manner throughout the living spaces.

The principle of the new system which has now been adopted in our most recent battleships and cruisers is that by means of an adjusted deflector projecting into the air duct a limited flow of air is directed into a large number of outlet gratings.

It was found that with a suitable but very simple and inexpensive form of grating the air passes out through it with a fairly uniform velocity at all parts. As, however, the area of the grating is considerable in proportion to the air allowed to issue through it, the velocity of the issuing air is low, and no unpleasant draught is perceptible at more than a foot away even when 100 cubic feet of air a minute are issuing from a grating of 18 by 6 inches. The grating is made of expanded steel, and it was found that a three-eighths of an inch mesh placed so that its direction tended to deflect the air at right angles to the trunk thus:

produced the best effect at a minimum of cost and weight. An endeavour was then made by varying the curvature of the deflector to obviate the inequality of distribution over the face of the grating, and experiments were made with deflectors:

(a) Concave, thus:

(b) Straight, thus:

(c) Convex, thus:

The distribution of the air was found to be a function of (1) the velocity of the air in the trunk flowing past the deflector; (2) the amount of opening of the deflector; (3) the shape of the deflector.

On the whole, the straight deflector proved to be the most satisfactory and was adopted in all subsequent experiments; and for gratings in the proximal end of the trunk nearest to the fan, where the velocities are high and the angle of opening of the deflector small, the straightness and truth of the deflector is of great importance.

As each deflector takes off a portion of the air flowing along a uniform trunk the velocity of air flow in the trunk beyond is correspondingly diminished; and since frictional resistance varies as the square of the velocity, there is a very marked reduction in frictional resistance. So important is this effect, that it was found that with a sufficient number of deflectors and gratings distributed along the sides of a uniform trunk of sufficient length the volume of air delivered was 93 per cent. of the delivery when no trunk at all was connected with the delivery side of the fan, there being, however, a trunk of about the ordinary length and size on the intake side, as would always be the case in a ship.

The deflectors themselves cause no material resistance. There is no difficulty in fixing them so that each gives practically the same delivery of air, a simple formula having been found by means of which this can be done without actual trial. The deflectors remote from the fan, where the velocity and pressure of the air in the trunk are small, require, of course, to be much more widely open than those close to the fan. Suppose the number of deflectors in a trunk is N , then the amount of opening of the R th deflector will be $\frac{1}{N-R+1}$ multiplied by the width of the trunk; thus, for example, the last must be full open, the last but one half open, and so on.

In a new ship the deflectors are first adjusted in accordance with the above formula, and then with the fan running under ordinary conditions each delivery opening is examined to see whether the velocity of air current is approximately the same at any portion of the trunk proximal or distal, and the deflectors are adjusted until this has been attained; but once equality of velocity has been secured the deflectors should be permanently fixed so that unauthorized persons shall not tamper with them and cause too great a draught in one place and a lack of air in another.

In the case of branch pipes it was found best to place a deflector at the junction and so control the delivery through the whole of the gratings on the branch. Each grating on the branch should also have its deflector. It was also found that it made no measurable difference to the amount of air distributed whether the branches came off at right angles or at the usual angle of 30 degrees.

If each grating measures 18 by 6 inches, which appears to be a convenient size, one is required for every two men

when 50 cubic feet of air per man per minute is supplied. This, of course, means a considerable number of gratings. On the other hand, the arrangement is simple, inexpensive, and efficient in preventing draughts and distributing air and warmth evenly throughout a compartment. Very favourable reports have been received from all ships so fitted.

Another great improvement effected during the war as a result of the Committee's recommendation is the introduction of a water-excluding ventilator, which is a modification of a fitting observed by the Committee in the French battleship *Courbet*.

Important compartments in the forward end of the ship, such as the seamen's latrines and the sick bay, both of which require specially good ventilation, were formerly entirely without it at sea, except in the calmest weather, simply because both the natural and artificial ventilation had to be closed to keep the water out. Now, however, the new fitting, by a combination of centrifugal action and drainage, guides any water which enters the ventilator back to the deck without permitting any of it to enter the fan or trunks. Consequently every compartment in the latest ships is just as well ventilated in the roughest weather at sea as it is in smooth weather.

Much, too, has been done to reduce the heat and stagnation of air in certain important compartments near the boiler rooms by the introduction of the traversing type of open propeller fan with the object of stirring up the air in accordance with Leonard Hill's results.

In 1915 the condition of living spaces during the long hours in which the ports and all means of natural ventilation have to be closed to exclude light came under consideration, and a number of light-excluding scuttle ventilators was supplied to every ship.

Special attention has been paid in the ships built during the war to the positions and ventilation of wireless offices, transmitting stations (which are the chief nerve ganglia in a ship), and to the space appropriated for treatment of the wounded during action, so that the atmosphere in each of them may be cool and fresh. Gunhouses and the silent cabinets in gunhouses have within the past twelve months been fitted with artificial ventilation which has been very favourably reported on by the Gunnery School at Whale Island. Destroyers are now fitted with pressure ventilating fans and the indirect system of heating the mess decks.

The ventilation of, and the method of purification of, the air in submarines have been greatly improved since the outbreak of war, and this is very clearly shown by the enormous reduction in the CO_2 content after long hours of diving. Traversing fans have been introduced into these vessels also.

Water Supply.

Before the war practically all drinking water consumed in ships in commission was distilled by their own condensers, but, for military reasons, a very large number of the smaller vessels and a few of the larger have, during the present hostilities, derived their water supply from the shore through the medium of water-carrying vessels, varying in size from small water boats of about 100 tons to large colliers. It was obvious from the commencement of this system that the transit from the standpipe on shore to the drinking tank in H.M. ships by way of hoses and tanks in water carrying vessels would be attended by a good deal of pollution, unless special precautions were taken, and even then some risk would be unavoidable; accordingly, the Admiralty issued orders that the work of cleaning tanks was in all ships to be carried out under medical supervision; that the clothing, including footwear, of the men who actually enter the tank was always to be previously disinfected; and that the work must be done by the ship, not by contractors, so that the men who carried it out could be under immediate control and supervision. Moreover, the process of supplying drinking water from standpipes on shore to tank vessels has for the past twelve months been under the supervision of naval medical officers, who draw up a few simple rules for the guidance of the men in charge of standpipes and for the masters of tank vessels. These rules are posted near the standpipes and in prominent positions in the tank vessels. Similarly the process of receiving water from a tank vessel into one of H.M. ships is always under the supervision of the medical officer of that ship or her parent ship, who

sterilizes the water with chloride of lime, however pure the source of the supply may be.

Further, a special naval medical officer is employed in

FIG. 1.—Neil Robertson Stretcher Open.

the sole duty of seeing that every precaution possible is taken to safeguard the water from pollution during its transit from shore standpipes to ship's tanks. He travels from port to port inspecting the water-carrying vessels to see that their fittings are in accordance with hygienic requirements and that the method of transferring the water is in accordance with the rules laid down by the Medical Department.

During the Gallipoli campaign a distilling apparatus of great capacity was set up in Mudros in order to provide the ships and the Naval Division with an ample supply of pure water.

As the sites of air stations have been selected primarily from a fighting point of view, the water supply, both as regards quantity and quality, has often proved a matter of difficulty and anxious consideration; it has then been necessary to arrange for sterilization by chlorination.

Unhealthy Occupations.

The composition used for the preservation of the fabric of aeroplanes contains material which, in civilian factories, has given rise to many cases of toxic jaundice, some of which have proved fatal. Although the Naval Air Service has used a very large amount of this "dope" no deaths, nor, indeed, any cases of illness entailing loss of service for a single day, have occurred. This fortunate result is to be attributed to widely disseminated information among the personnel as to the danger to be guarded against, efficient artificial exhaust arrangements (giving thirty changes of air per hour in doping rooms) and complete organization for extensive alternation of work.

The "dope" used in varnishing air-ship envelopes is of an entirely different nature, and in the absence of protective measures causes symptoms resembling acute alcoholism; but here again, although several hundreds of men are employed continuously at this work no ill effects can be traced to it owing to the efficient methods of immediately removing the fumes by a large number of powerful exhaust fans.

In our munition factories 5,000 men and women handle tri-nitro-toluene (T.N.T.), but no dust is allowed to collect, and the regulations for the protection of workers have been so strictly carried out that not only have there been no fatal cases, but there is no record of a single case of toxic jaundice. Although many authorities believe that the poisonous agent in T.N.T. is introduced through the skin, it is considered unjustifiable to allow the fumes of melting T.N.T. to escape into the general atmosphere of the room, and in all our factories artificial exhaust arrangements have been fitted to remove the fumes from their point of origin.

THE SERVICE AFLOAT.

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ALL senior medical officers afloat of the Royal Navy appreciate the work of preparation which has been steadily going on for many years, most markedly in the last decade, in the Service. The plans laid down in peace time for the rapid expansion, when war should be declared, in personnel and stores, all bore fruit when put to the test in 1914, and this expansion still continues.

The installation about six years ago of high-pressure steam disinfectors in ships has, since the outbreak of war, proved of supreme value. Besides providing a weapon to combat the exanthemata and other infectious diseases as well as scabies, they sterilize clothing and dressings as frequently as may be desired. Another great improvement of pre-war times was the replacement of the clumsy service stretcher by the two forms of stretcher now in general use—(1) the bamboo stretcher designed from the Japanese stretcher by the late Fleet Surgeon Neil Robertson, R.N. (Figs. 1 and 2), which renders possible the removal of wounded from small compartments, down escapes in turrets, and round difficult corners with a minimum of danger and discomfort, and (2) the ambulance field service stretcher (Fig. 3), which enters so largely into the scheme for increased stowage space by the tier system, as explained further on (Figs. 4, 5, and 6).

At the outbreak of war the supply of stores and instruments increased automatically, and catgut, silk, and the like were sent to ships in portable tubes ready sterilized. The ships have always been on a war footing, but much has been learnt since the start of hostilities, notably the

FIG. 2.—Neil Robertson Stretcher with Patient.

large number and severity of burns encountered in action. Pictures of bluejackets working their guns stripped to the waist are picturesque reminiscences of the past, but the battle of Jutland showed that exposed parts, such as face,