ASBESTOS - A POTENTIAL HAZARD TO HEALTH IN THE SHIP BUILDING AND SHIP REPAIRING INDUSTRIES.

J. D. WALTERS,
M.B.,B.S.,D.I.H.

Surgeon Lieutenant, Royal Navy.

D.P.H. COURSE 1958-59.

LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE.

INDEX.

Note: Photographs are mounted opposite the text they are desired to illustrate.

ASBESTOS - A potential hazard to health in the Ship-building and Ship-repairing Industries.

Surgeon Lieutenant J. D. Walters,
M.B.,B.S.,D.I.H., Royal Navy.

Large quantities of asbestos are used in the building and repairing of ships. Much is used in easily recognizable form and some is incorporated into materials which bear little or no superficial resemblance to the crude fibre at all, but which may still give rise to a highly dangerous dust when sawn or otherwise manipulated. The inhalation of this dust over a period of time gives rise to a very disabling and sometimes fatal form of pneumoconiosis known as asbestosis, and it is the aim of this article to discuss the prevention of this disease in Dockyard workers.

The subject is not an easy one because asbestos has found applications in so many different fields of industry that it is difficult to decide which workmen are exposed to a significant hazard and those that are not. Obviously it is essential, therefore, that the Industrial Medical Officer should know something of the composition of the asbestos-containing materials in use and their method of application. There is a paucity of literature dealing with this subject in language intelligible to the average Medical Practitioner, and it is hoped that the information collected and presented here may be of some assistance to industrial Medical Officers, particularly those employed in Dockyards.

The material for this article has been collected from many different sources. Most of the data concerning the asbestos workers, the photographs and case records were obtained whilst the writer was Assistant Medical Officer at Her Majesty's Dockyard, Portsmouth. A very brief account of the clinical and pathological aspects of asbestosis was extracted from the vast body of literature on the subject of pneumoconiosis, and also from other records. For the technical information, the writer is deeply indebted to all the manufacturers and other experts in various fields whose enthusiastic support, given by means of the written word and personal contacts, has been humbly acknowledged in the appropriate section of this paper.

Finally, it should be said that, owing to the great number of asbestos products commercially available, it has not been possible to mention all of them. It is hoped, however, that a representative sample has been taken of the materials most commonly used in ships of the Royal and Merchant Navies.

I.

ASBESTOS - THE RAW MATERIAL.

(a) The Preparation of Asbestos.

Asbestos is a natural mineral fibre. It is unique in that it is completely incombustible - unlike fibres of animal or vegetable origin which all burn more or less freely.

Deposits of asbestos are found in many different parts of the world, notably South Africa, Canada, Rhodesia and the U.S.S.R.. It occurs in seams of rock lying between greater thicknesses of rock of similar chemical composition. When milled the asbestos rock breaks down into fibre whereas the accompanying non-fibrous rock is reduced to powder. Why seams of asbestos should be laid down in this way is not exactly known, but asbestos is entirely a mineral substance, unlike coal for instance.

Asbestos is obtained from open quarries or shallow mines by the usual methods of drilling and blasting. It is separated from the waste rock, dried and then crushed, the foreign matter being removed by screening. The crude asbestos, graded according to length of fibre, is first crushed and rolled to separate the fibres. Particles of stone and iron are removed by means of a centrifugal separator and by passage over an electro-magnet. The next process, known as "opening", further separates and loosens the fibres, leaving the asbestos in the form of a light fleecy down with the individual fibres lying in all directions.

For some purposes the fibre may be used in this form. To make it suitable for spinning, however, it must first be "carded" to bring the fibres to lie in one direction only. This process converts the mass of asbestos fibre into "sliver" or lightly twisted strip ready for spinning. The yarns produced are "doubled" to the requisite number of plies and then passed to the looms or braiding machines. During the "doubling" process, wire or vegetable fibre such as cotton may be incorporated into the yarn.

Manufacturing processes all tend to the dusty and present a serious industrial problem, though the discussion of them lies somewhat outside the scope of this paper.

(b) <u>A General Survey</u>.

Asbestos has been known for a very long time - at least 2000 years, and it is otherwise called earth flax, stone flax or mountain cork. Herodatus (450 B.C.) describes the use of asbestos cloth by the Romans to enshroud corpses prior to cremation, and thus facilitate the collection of the ashes. Asbestos was then obtained from deposits in the Italian Alps and the Ural Mountains. Pliny (A.D.50) wrote of the difficulty of weaving asbestos and referred to the wearing of respirators to prevent the inhalation of dust. From Plutarch (A.D.70) it is learnt that the wicks of the Vestal Virgins' lamps were made of asbestos. It is also said that Charlemagne possessed a tablecloth which could be cleaned by passage through fire.

The use of asbestos on a big scale is much more recent and dates back only to about 1890. In 1880 world production was 500 tons annually, whereas it had risen to 1,300,000 tons per year by 1951. Probably the advent of steam propulsion and the production of steel ships were two of the main reasons for the widespread introduction of asbestos into the ship-building and ship-repairing industries.

In a steam driven steel ship there is obviously a serious lagging problem. From the purely engineering point of view, an efficient, robust and fireproof material is required to lag boilers, pipes and turbines and other such things. It is also necessary to insulate the interior of the vessel from the external environment by lagging deckheads and ships sides in order that reasonable standards of habitability may be maintained under all climatic conditions. Lagging bulkheads with asbestos or certain other fireproof materials effectively insulates the compartments of the ship from the thermal and sound points of view, and also renders such bulkheads fire resistant. The International Convention for the Safety of Life at Sea, 1948, and Rule 44(I) of the Merchant Shipping (Construction) Rules, 1952, lay down the standards required in such fire resisting divisions.

Apart from these major uses for asbestos in the shipping industry, there are innumerable minor, or relatively minor uses for this versatile material. Indeed, it would be almost impossible to enumerate all the products in the manufacture of which asbestos is exclusively or partly used. In any situation in which a material is required which will insulate against electricity, heat and sound, which is absolutely fire-proof, undecaying and resistant to water, acids and alkalis, that is porous, flexible and capable of being spun, asbestos or an asbestos product finds an application. More uses for the material are constantly being discovered.

The use of asbestos products in various lagging operations is described elsewhere in this article, and most of the asbestos used in the industry is utilised in this way. But it is interesting in passing to mention a few other forms in which asbestos may be found in a dockyard. For this purpose the products may conveniently be divided into those that are in textile form and those that are not.

Asbestos yarn, woven into cloth, isused in the manufacture of covers for insulation mattresses, filtering materials, fire curtains, fire smothering blankets and fireproof clothing. Pieces of asbestos cloth may be used to cover hot forgings and castings in order that they may cool slowly. In narrower widths asbestos cloth may be made into beltings of various kinds, brake linings and insulating tape. When rubber-proofed it may be used in making steam packings and jointings. The yarn itself, or in combination with wire or cotton, may be used for sewing up articles made of asbestos cloth and may also be found in the seams of incandescent gas mantles.

Non-textile forms of asbestos include such materials as asbestos cement sheets, tiles, pipes and other building materials, or it may be bonded with bituminous substances for use as flooring materials or switchboard panelling. Asbestos is also a constituent of brake and clutch linings and packing materials. It may be used in making heat resistant electric cables and for covering electrodes used in welding. Large quantities of asbestos, particularly short fibre asbestos, is used in the plastics industry and also as a filler in the manufacture of paint and asbestos putty. Considerable amounts of asbestos are incorporated in the casings of electric accumulators.

It is not claimed that the use of all these forms of asbestos necessarily constitutes a significant hazard to health. On the other hand, it is interesting to note the versatility of asbestos before considering some of the processes in which a very definite hazard exists. Neither is it claimed that the hazards faced by asbestos workers in the ship-building and ship-repairing industries differ materially from those faced by similar workers elsewhere. But it is thought that certain aspects of their work are worthy of consideration and it is intended to discuss some of these aspects at a later stage, and perhaps make reference to measures which could be taken to safeguard the health of the asbestos worker beyond those already required by statute.

(c) Types of Asbestos.

The term asbestos covers a wide variety of silicate materials of different chemical compositions and physical properties. They are compounds of silica and a metallic base, usually magnesium or iron but sometimes of calcium, sodium or aluminium. All have a fibrous structure, and any given piece of asbestos rock is capable of being divided and sub-divided along its length indefinitely until the fibres so formed reach molecular diameter.

The fibres are of great flexibility and are suitable for spinning and weaving. They are incombustible, highly resistant to chemical action and possess insulating properties with respect to heat and electricity. Different varieties of asbestos possess these properties in different degree. In size the fibres vary greatly, even in a given variety of asbestos. The smallest fibres are not visible to the most powerful optical microscope, and lengths vary from small fractions of an inch to 43 inches.

Of the various types of asbestos known, the types of most importance to industry may be classified under the two headings chrysotile (serpentine) and amphibole (horneblende) asbestos.

(i) Chrysotile (Serpentine) Asbestos.
$Mg_3 Si_2 O_5 (OH)_4$

90% of the world's production of asbestos is of this type of fibre. It is white in colour, of fine texture, silky sheen, and the fibres are mainly short. Canada is the main source of supply, but Russia, Rhodesia, South Africa and Australia also have deposits of chrysotile asbestos. The special properties of chrysotile render it a very suitable material for spinning, weaving into cloth or for the making of asbestos ropes. Also, the high magnesia content of chrysotile provides the natural lubricant so necessary for the manufacture of engine packings for stuffing boxes and glands.

(ii) Amphibole Asbestos

This type of asbestos is more variable in composition than chrysotile. It occurs mainly in South Africa, and the three principal varieties are amosite, crocidolite and tremolite.

Amosite. The iron in amosite gives some specimens a dirty brown colour. Although the fibres are normally several inches long they are of poor spinning quality but, owing to its great specific volume on fiberisation, it is a most useful material for use as a thermal insulator. For this purpose it may be used as a flock, or moulded into blocks, slabs or pipe sections. Large quantities of amosite are also used as a binding material in asbestos cement sheets, pipes, gutters and similar products. It has great resiliency, will withstand very high temperatures and is very resistant to the action of acids, alkalis and sea water.

Most of the amosite used in the United Kingdom is derived from deposits in the Transvaal and Cape Province of South Africa.

Crocidolite Asbestos - Horneblende.
$3Na_2O.6Fe\ O.\ 2Fe_2O_3.16SiO_2.H_2O.$

Otherwise known as blue asbestos or Cape Blue, the largest deposits of this mineral are in the Cape Province of South Africa. The presence of ferrous oxide in crocidolite is responsible for its blue colour.

The properties of crocidolite are similar to those of amosite. It possesses great tensile strength - much more than chrysotile, has great resiliency and specific volume, and is able to withstand high temperatures. The remarkable resistance of Cape Blue to the action of acids, alkalis, chemical solutions and sea water have commended it to many industries. Among these may be mentioned the railway industry, which uses insulating mattresses made entirely of blue asbestos for lagging the boilers of locomotives. The electric accumulator industry incorporates a considerable amount of blue asbestos fibre in the casings of accumulators. Usually the longer fibres are used in the manufacture of blue asbestos cloth and the shorter fibres are those generally used as a filler in the plastics and rubber industries.

Tremolite.
$Ca_2Mg_5Si_8O_{22}(OH)_2$

This is a white asbestos found chiefly in Italy. The outstanding feature of tremolite is the remarkable length of its fibre, single fibres of 43 inches long having been found. The fibres are, however, very brittle and this makes it unsuitable for spinning and weaving. Accordingly, it is used mostly in thermal isulation work. It is not widely used in Great Britain.

Chart to show a typical comparative analysis of the main types of asbestos.

	CHRYSOTILE. White asbestos %	AMPHIBOLE ASBESTOS Crocidolite (Blue) %	Amosite %
Silica	40.5	51.9	47.4
Alumina	0.7	0.2	4.5
Ferrous Oxide	1.0	19.2	36.6
Ferric Oxide	1.5	18.4	3.3
Calcium Oxide	-	0.2	0.8
Magnesia	42.6	1.4	5.8
Alkalis (as Sodium Oxide)	-	6.1	-
Water (chemically combined)	13.7	2.6	1.6

It has been shown that the structure of the fibre of chrysotile differs from that of amphibole asbestos. The former is thought to have a hollow fibre whereas amphibole fibres are said to be solid throughout. This difference could explain certain differences in the physical properties of the two forms. For instance, chrysotile is soft and absorbent whilst amphibole is springy and brittle. When fiberised, the stiff fibres of amphibole asbestos form a scaffolding which encloses innumerable air cells, giving it a great specific volume and thus becoming an excellent thermal and sound insulator. White chrysotile has not the same degree of flocculence as amosite asbestos, and whereas asbestos itself has some degree of non-conductivity to heat it is the capacity of the fiberised asbestos to hold within its mass a large number of air cells which determines its effectiveness as an insulator for both heat and sound.

II.

THE HAZARD - ASBESTOSIS.

HISTORICAL.

Pneumoconiosis has been defined as "a fibrosis of the lungs due to silica dust or other dust, and includes the condition of the lungs known as dust reticulation." That form of pneumoconiosis caused by the inhalation of asbestos dust is called asbestosis.

The first case of this condition to be described is referred to as the Montague Murray case. In 1906 Dr. Montague Murray was giving evidence before the Departmental Committee on compensation for industrial diseases when he described the case of a 34-year-old asbestos worker who died in the Charing Cross Hospital in 1900. Autopsy had confirmed the clinical diagnosis of an extensive non-tubercular pulmonary fibrosis. The patient had said that some ten of his workmates had died at about the age of thirty years.

A survey into the hazards of the asbestos industry carried out in 1910-11 did not reveal any evidence of a serious hazard to health, but in 1912 it was shown that a mild degree of pulmonary fibrosis could be produced in experimental animals by causing them to inhale asbestos dust.

Cases of possible asbestosis were reported from time to time after this survey. Cooke reported one in 1924, but it was a case of extensive non-tubercular fibrosis of the lungs in an asbestos worker, described by Seiler in 1928, which caught the public eye. Seiler's patient was seriously disabled by his disease and required hospital treatment. This case seemed to establish beyond reasonable doubt that a relationship existed between the inhalation of asbestos dust and a disabling, possibly fatal pulmonary fibrosis.

Following the description of Seiler's case, an enquiry into the Abestos Manufacturing industry in Great Britain was undertaken by Merewether and Price at the instigation of the Home Office. This investigation was carried out in the years 1928-29 and was a very extensive and thorough inquiry. Their report, published in 1930 by H.M. Stationery Office, was entitled "A Report on the Effects of Asbestos Dust on the Lungs and Dust Suppression in the Asbestos Industry." The report makes interesting reading and remains a classic and authoratative account of the asbestos industry and asbestosis.

PATHOLOGY.

The dust arising from the use of asbestos is a fine dust consisting of needles or spicules of asbestos and is sometimes described as a "thistledown" dust. When inhaled most of the particles are trapped by the mucus of the upper respiratory tract and trachea, but some may penetrate lower down into the bronchi, bronchioles and even the alveoli. Particles which are retained in the alveoli must obviously be very small but the larger particles may, because of their physical form, be trapped in the smaller respiratory passages.

Inhaled asbestos fibres are thought to produce fibrosis by mechanical irritation of the respiratory tract unlike the causation of silicosis which is probably a result of chemical irritation. This "mechanical irritation" theory is well supported by the work of King, Clegg and Rae (1946), who showed that the inhalation of aluminium dust by rabbits subjected to intratracheal injection of asbestos dust did not prevent them from developing a pulmonary fibrosis. It will be remembered that such therapy helps to prevent silicosis. Probably a layer of insoluble and impermeable hydrated alumina is deposited over the particles of silica in the tissues and thus reduces their toxicity. Possibly this is an over-simplification but it is sufficient for the present purpose.

Other facts are also available to support this "mechanical irritation" theory. For instance, asbestos fibres are very flexible, unlike those of glass and this may be the reason why asbestos is fibrogenic and glass is not. On the other hand, fibres of brucite ($MgO.H_2O$), a fibrous mineral often found in association with deposits of asbestos, are also less flexible than asbestos fibres and are fibrogenic. It has also been pointed out that asbestos fibres have only been shown to produce fibrosis in areas where there is constant movement, for example in the lungs and peritoneum, and never in the spleen or liver.

The problem of finding which size of fibre is the most fibrogenic is a difficult one. Key showed that the intra-tracheal injection of long fibres (15 microns) produced a nodular reticulinosis rather like experimental silicosis, but short fibres (2.5 microns), given by the same route, produced a diffuse reticulinosis. In 1951 Vorwald et al compared the fibrogenic activity in guinea pigs of asbestos fibres of 3 microns in length with those of 20-50 microns, both being given by the intra-tracheal route. The longer fibres were found to be the more fibrogenic but it would be unwise to assume that these results are necessarily applicable to the human subject. Considerable technical difficulties are met with in such investigations such as the maintenance of an atmosphere of standard dustiness, for man is not likely to receive his asbestos dust intra-tracheally. Probably fibres of up to 20 microns are the most dangerous, although fibres of over ten times that size have been detected in the human respiratory system.

Owing to the irritation caused by trapped asbestos fibres, desquamation of the pulmonary epithelial cells occurs and fibroblasts appear around the bronchioles and alveoli. The final stage is the deposition of collagenous fibres around the distal ramifications of the respiratory tract. There is no local necrosis or leucocytic reaction to the presence of asbestos fibres in the lung.

The asbestosis lung at autopsy is generally firm and airless and covered with a very thickened pleura. This pleura is of glistening yellow colour and may be raised into folds and insinuate itself into all the various fissures and sulci. The fibrotic condition of the lung is immediately obvious when cut with the knife. Characteristically, blue-black polygonal areas may be seen over the whole of the cut surface of the lung which correspond in size and shape to the pulmonary lobules. This picture may of course be considerably modified according to the nature of the terminal illness. Other organs are not directly affected, although they too may have been affected as a result of the terminal illness.

Under the microscope, sections of affected lung tissue may be seen to contain asbestos fibres in the alveoli and bronchioles, and also in the connective tissues and lymphatics. Plugs of desquamated epithelium may be seen in the main air ducts, particularly in the region of the terminal bronchioles, in which may also be seen large numbers of large mononuclear phagocytes. These phagocytes and dust particles may completely obliterate the lymphatic channels. Much connective tissue surrounds the bronchioles, air sacs and alveoli as well as the blood vessels, and in the most extreme cases the normal lung structure may be completely obliterated by the fibrous tissue.

Regularly found in sections of lung from asbestosis cases are curious bodies of golden yellow colour. These are called asbestosis bodies and were first described by Stuart McDonald in 1927. Apart from lung sections, they may also be found in the sputum, pleura and faeces of people exposed to asbestos dust. They are recognised as being due to the inhalation of asbestos dust and also as being formed from the original inhaled fibre following the deposition upon it of material derived from the tissue fluids. This deposition thickens the fibre and it assumes a shape resembling a dumb-bell. In course of time fragmentation of the asbestosis body takes place and it then looks like a microscopic string of beads. Finally, a complete dissolution takes place and only a number of granules remain from which the original shape of the asbestosis body may be surmised. Whilst there is marked variation in the size of these bodies, 24 - 60 microns in length would be a reasonable average.

Probably the formation of these bodies is part of the process by which the human body attempts to detoxicate asbestos. It has been shown that the intra-pulmonary injection of guinea-pigs with asbestosis bodies does not give rise to fibrosis, whereas the injection of asbestos fibres will produce that effect.

The presence of asbestosis bodies in the sputum of workers exposed to asbestos is not evidence that that worker has asbestosis, indeed they have been found in the sputum of people exposed to such dust for only two months. Even casual exposure may be sufficient to cause the appearance of asbestosis bodies in the sputum at a later date. On the other hand, if clumps of these bodies appear in the sputum it may be taken as evidence that disintegration of lung tissue is occurring, and strongly suggests the presence of established asbestosis.

In this section an attempt has been made to review the pathology of asbestosis. Necessarily, the subject has been dealt with in a very cursory fashion and for more detailed information the reader is advised to consult the vast amount of literature on this subject. It is hoped, however, that sufficient has been included to serve as a background against which the clinical and preventive aspects of the disease may be considered.

III

THE DIAGNOSIS OF ASBESTOSIS.

The diagnosis of asbestosis is made in much the same way as that if any other form of pneumoconiosis. A full occupational and medical history must be taken, a thorough physical examination made and also an X-ray of the chest. Owing to the fact that the hazards of working with asbestos dust are now so widely known and the routine medical examination of workers exposed to such dust is commonplace, cases of asbestosis are now seen much earlier than was the case years ago. Indeed, cases may present themselves for diagnosis before the disease has had time to fully develop. Such cases are frequently difficult to diagnose even now that the disease is so much better understood, and in spite of the great advances in radiographic techniques.

It therefore behoves the Factory Medical Officer to be most diligent in his search for the symptoms and signs of asbestosis if cases are to be diagnosed at the earliest possible moment.

The Occupational History.

This part of the investigation has been considered first because cases with asbestosis may present for examination before any definite physical signs or radiological evidence of asbestosis can be obtained. In such cases a history of employment in a job involving exposure to asbestos dust may well be the vital clue to the diagnosis.

In taking the occupational history it is necessary to note down every job the patient has ever done and the periods of time during which they were employed in each job. Any suggestion of exposure to a fibrogenic dust should be most carefully investigated, even though it may have been many years since the patient was so exposed. For, whilst asbestosis appears characteristically in workers who have been employed in handling asbestos products for several years, cases have been recorded where a short, but intense exposure to the dust has resulted in a disabling asbestosis many years afterwards. In one such case the period of exposure was only nine months.

There are also cases where female workers, having left the asbestos industry on marriage, are later found to have asbestosis only when they are investigated for unexplained breathlessness during pregnancy. In these cases the enlargement of the uterus further embarrasses their respiratory system. There is also evidence to suggest that after many years of exposure to asbestos dust, an attack of bronchitis, or other respiratory infection, may initiate a rapidly developing pulmonary fibrosis in patients who had previously shown no evidence of asbestosis.

It is possible, of course, that even knowledge of the patient's job would not immediately suggest an asbestos hazard. Clearly the Medical Officer should be well informed as to the great number of forms in which asbestos may be used. Cases have occurred where the patient himself had no idea that he was using asbestos at his work, and yet he contracted asbestosis. Such situations may arise in shipwrights working with asbestos panelling and in the paint and plastics industries where asbestos is used as a filler.

The importance of an accurate and detailed occupational history is obviously of prime importance in the diagnosis of asbestosis, and no time spent questioning the patient or investigating his conditions of work should be considered wasted.

The Clinical Examination.

Clinically, the most outstanding symptom is dyspnoea, which may be out of all proportion to the physical signs. In these days, when asbestosis is becoming a more chronic disease affecting mainly older men who have served many years in the industry, it is important that slight breathlessness, occurring at first on exertion only, but becoming worse, should not be overlooked. These middle-aged men are apt to explain their slight dyspnoea by reference to age, "middle-aged spread", smoking, or some other reason, in spite of knowing the hazards of their work.

As time goes on the dyspnoea becomes worse and may be associated with an unproductive cough, transient pleural pains, and a tendency to bronchial colds which do not readily clear up. From an early stage in the disease, showers of persistent, fine crepitations may be heard, particularly over the bases of the lungs. They are probably caused by obstruction of bronchioles by asbestos fibres and this theory is supported by the simultaneous appearance of altered fibres in the sputum. Whilst the hearing of these crepitations is a valuable physical sign, their appearance is not diagnostic of asbestosis as they have been heard in workers with only a few weeks' service in the industry, and who do not show any other sign of disease.

Eventually the fibrosis becomes sufficiently severe to be completely disabling. In this stage of the disease the chest wall tends to become rigid and smoothly flattened in front. The shoulders become raised, and movement, though symmetrical, is very limited. There may be a resonant percussion note due to emphysema, or patches of dullness overlaying areas of thickened pleura may be found.

In addition to all the signs of pulmonary fibrosis, advanced cases may show evidence of cardiac distress.

Characteristically, there may appear an earthy cyanosis of the malar region, lips and ear lobes, and quite a degree of drum-stick clubbing of the fingers and possibly toes as well. Twenty-nine of Wyers' series of fifty-three consecutive cases showed this clubbing.

Like other forms of pneumoconiosis, the disease tends to be progressive and if exposure of the patient to asbestos dust continues, then severe disablement or death may ensue. No cure is known, so that it becomes all the more important that cases should be recognised as early as possible in the disease and that they be removed from further exposure to asbestos dust. The all important question of prevention is discussed elsewhere in this paper.

Complications of Asbestosis.

There is not the same close relationship between asbestosis and pulmonary tuberculosis as exists between silicosis and tuberculosis, although cases of asbestosis complicated by tuberculosis have been described. For instance, Cooke's case, described in 1924, would have been a more convincing demonstration of the relationship between the inhalation of asbestos dust and pulmonary fibrosis had not a chronic tubercular infection been present in thesame case. There is, however, a large body of information to suggest that carcinoma of the lung is more common in asbestos workers than in the general population.

In the Annual Report of the Chief Inspector of Factories, 1947, Merewether stated that carcinoma of the lung was notified in 31 out of 335 cases of asbestosis (13%), but in 91 out of 6,884 cases of silicosis (1.3%). These findings agreed with those of Gloyne, whose figures were 14% and 6.9% respectively. If only male patients are considered, then 17% of the group studied by Merewether died of lung cancer and 20% of Gloyne's.

More recently, Doll studied records of a group of 105 persons who died after working in the asbestos industry. 18 had lung cancer and in 15 of these the cancer was associated with asbestosis. He also compared the mortality of a group of 113 men who had worked more than 20 years in the asbestos industry with a similar group in the general population. 39 deaths occurred in the first group when only 15.4 were expected, the excess being due to lung cancer, other lung diseases and cardio-vascular diseases. He stated, "from the data it can be concluded that lung cancer was a specific industrial hazard of certain asbestos workers, and that the average risk among men employed for twenty years or more has been of the order of ten times that experienced by the general population." It was pointed out, however, that the workers examined had worked in the industry before the pathogenic nature of the dust was recognised, and before the introduction of the Asbestos Industry Regulations, 1931, which controlled conditions in asbestos factories.

In the face of this evidence, it is difficult to understand why there is still doubt in some circles as to the relationship between lung cancer and asbestosis. Lanza, in a paper read in 1952, stated that he had found no evidence of such an association in either American or Canadian asbestos workers.

Apart from carcinoma of the lung, other terminal conditions may be congestive cardiac failure and broncho-pneumonia. Oddly enough, however, frank infective bronchiectasis is unusual, despite the frequency of finger clubbing.

The Radiographic Examination.

The chest X-Ray of a suspected case of asbestosis is a valuable adjunct to the occupational history and clinical examination of the patient. Frequently, however, the clinical signs are present before any radiological changes are evident, and in early cases the clinical findings are the most reliable guide. To be of most help, the X-Ray film should be of high technical quality and be viewed by a good light.

Characteristically, the chest looks small from apex to base. Next there may be seen a general haziness of the lung fields described as a "ground-glass" appearance. Later, the lung fields may become finely mottled or stippled, either locally or generalised, but with a tendency to be more obvious in the lower halves of the lung fields. If the mottling becomes coarser then a granular pattern may be seen.

After these stages the appearances become those of a sclerotic pleurisy with obliterations of the costo-phrenic and cardio-phrenic angles. The cupolae of the diaphragm and cardiac shadow appear shaggy. Wyers likened the appearance to that of teased-out cotton wool. Sometimes it is possible to see a characteristic thickening of the horizontal fissure which may run obliquely instead of horizontally.

The question of differential diagnosis does not usually arise where there is an accurate occupational and clinical history, and chest X-Ray should not be relied upon to detect an early case of asbestosis. But in examining X-Rays of asbestos workers it is important that evidence of tuberculosis and other respiratory diseases should not be overlooked. Indeed, the detection of such conditions must be one of the primary tasks when undertaking the routine chest X-Ray of asbestos workers.

IV.

THE PERSONNEL AT RISK.

It has been pointed out earlier in this article that there are but few spheres of industry in which asbestos is not used in some form or another, but it would not be true to say that an appreciable asbestosis hazard exists in all such occupations. For the present purpose, it is proposed to discuss only the work done by the "asbestos workers" in H.M. Dockyard, Portsmouth. All these men are engaged in lagging work of one kind or another, and it is considered that most of them are exposed to the risk of asbestosis.

Although asbestos had been used in the Dockyard for many years prior to 1946, it was only then that the lagging parties, composed of full-time laggers, were formed. Before that date, small lagging jobs, such as patching up insulation after inspection of machinery by a fitter, was done by the fitter's mate. Bigger jobs were done by contractors. A few men were engaged before 1946 making asbestos mattresses, but in most cases these men both made and fitted the mattresses themselves.

"Asbestos workers" are employed by the Constructive Department and also by the Engineering Department of the Dockyard. Whilst the raw materials with which these two groups of laggers work are basically similar, the jobs they do are slightly different, and so they will be described separately.

The "Limpet Asbestos Workers".

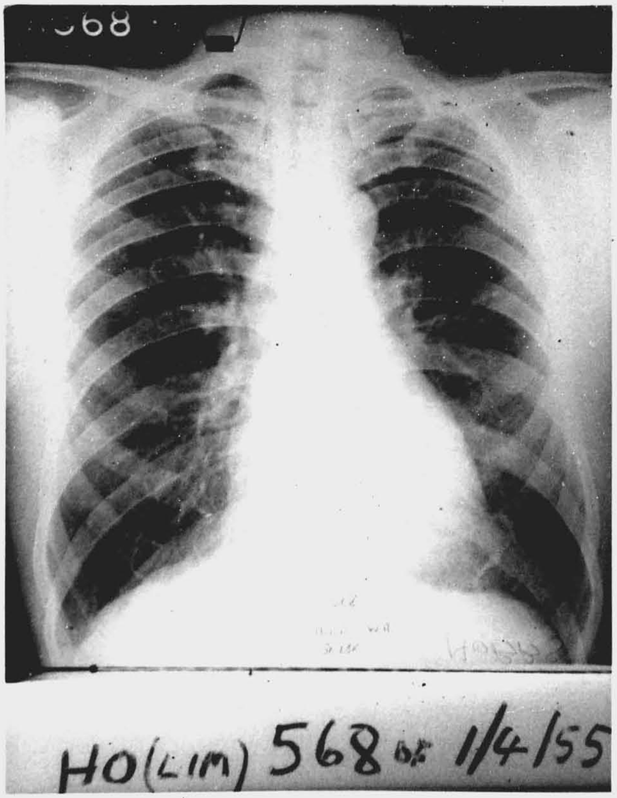
These men are employed by the Constructive Department. Their title is derived from the fact that they are engaged upon the spraying of asbestos fibre on to bulkheads and deckheads of ships, a process called the "Limpet Asbestos" process by Newall's Insulation Co.Ltd. A similar process is the "Silbestos process", so called by Dick's Asbestos and Insulating Co. Ltd.

In 1946 there were only six men engaged in this work in the Dockyard, but by 1953 the number had increased to 26. The total fell to 19 by 1958 and it may well fall further since less of this type of work is now undertaken. Most of the work is the making good or repairing of existing sprayed asbestos insulation.

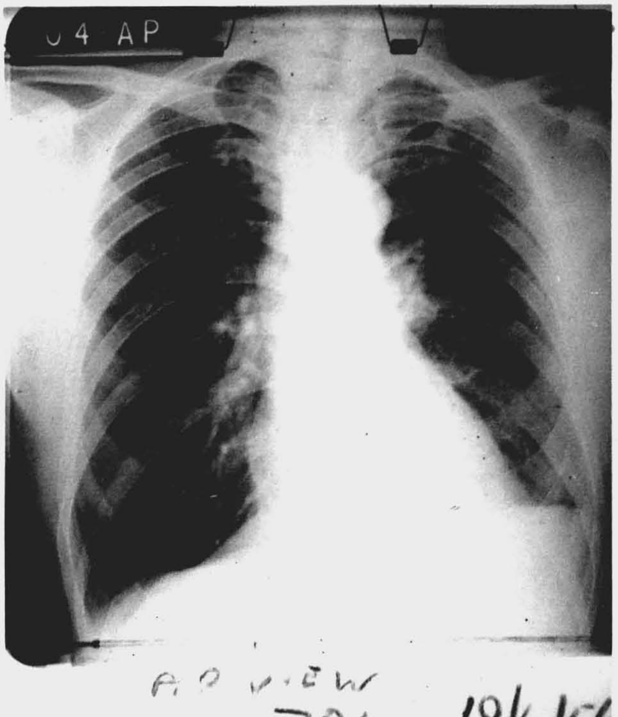
Applicants for employment on this work are examined medically and radiologically before training. Thereafter they are medically examined every six months and a full-plate X-Ray of the chest is taken annually, the films being examined by the Radiologist at the Royal Naval Barracks, Portsmouth.

During the twelve years that these men have been

Chest X-Rays relevent to the case described on page 33



(1) Normal film taken in 1955.



(2) Film taken in 1956 showing the suspicious appearances in the left lower zone.

under observation, no case of asbestosis has been found, and only one man removed from the work for health reasons. This man was aged 54 and at routine chest X-Ray a suspected carcinoma of the lung was found. A long series of investigations at the Chest Clinic and Hospital was required before the diagnosis was disproved. The shadow in the lung eventually disappeared, but the job given to the patient during his investigation period suited him so well that he decided against returning to his former occupation.

Photographic reproductions of his chest X-Rays are appended, and whereas they do not show asbestosis the findings demonstrate the kind of problem which may well confront an Industrial Medical Officer, who may be asked to say whether or not a man should give up his hazardous occupation. In this example, the man himself solved the problem and in any case his pleural effusion, which was the final diagnosis, cleared up.

Two other men were "picked up" at routine X-Ray in 1953 and referred to their own doctors, who in turn passed them on to the local Chest Clinic. Both men had histories of pneumonia and were kept under observation as out-patients for some time. Pneumoconiosis, active tuberculosis, or carcinoma of the lung, were diagnoses considered possible in one case, and pulmonary tuberculosis in the other, but in July 1958 both men were fit, at their normal work, and their chest X-Rays were within normal limits.

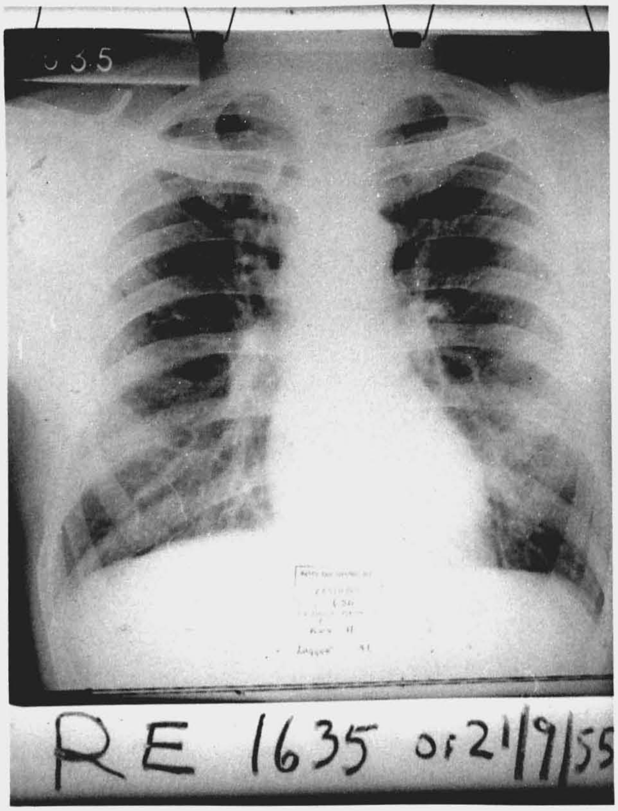
The "Laggers".

Although the "Limpet Asbestos Workers" are also laggers, the title "lagger" is commonly applied in Portsmouth Dockyard to those asbestos workers employed by the Engineering Department. Their main function is to insulate engines, boilers, steam pipes and other such structures.

Whilst all the laggers are considered under a single heading, about ten of them have the distinction of being the only ones covered by the Silicosis and Asbestosis (Medical Arrangements) Scheme, 1931. As such they are required to have an initial and periodic medical examination by a member of the Pneumoconiosis Medical Panel. Their job consists of making the asbestos mattresses required for insulation purposes and some photographs of the men engaged in this work are included in the section dealing with asbestos processes.

The total size of the lagging party varies but is usually about 70 men. Every man, regardless of the absence of a statutory requirement, is examined medically and radiologically before being employed and annually thereafter. Any "pick-up" is referred to his own doctor, who invariably passes him on to the Chest Clinic for investigation.

The chest X-Ray relevent to the case of Mr. R..



This film, taken in 1955, shows early asbestosis.

Between 1955 and 1958, 25 prospective trainee laggers were examined and 4 were rejected on medical grounds. In three cases there was evidence of chronic bronchitis, one having a gross kyphoscoliosis as well, and the fourth case was one of active pulmonary tuberculosis. The value of pre-employment medical examination would therefore seem to be established.

During the same period of time, 3 men were suspended from lagging work on medical grounds. The first was a definite case of asbestosis, the second a frank case of bronchiectasis, and the third a severe chronic bronchitic. The decision to suspend the men was taken with the full agreement of the Chest Physicians supervising their treatment. The case of Mr. R., who was found in 1955 to be suffering from asbestosis, is quite typical and a summary of his case notes is included here for general interest.

Mr. R. Age 41 years. Chargeman of Laggers.
Duration of exposure to asbestos dust approx. 23 years.

In September 1955 Mr. R. had his chest X-Rayed at the Royal Naval Barracks, Portsmouth. A photographic reproduction of the film is appended, and it may be seen that an early pneumoconiosis was present. Clinically, his only symptom was a very doubtful dyspnoea on exertion.

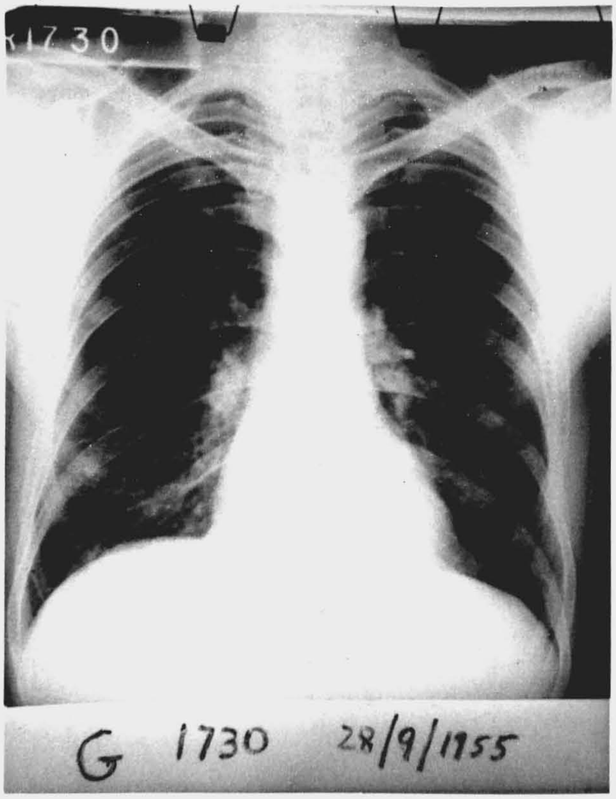
The film was sent to a member of the Pneumoconiosis Medical Panel for an opinion, and a diagnosis of asbestosis was suggested. Accordingly, Mr. R. was advised to apply for a Medical Board to the local office of the Ministry of Pensions and National Insurance. This application was made and in due course the Senior Medical Officer of the Dockyard was asked to furnish the local Insurance Officer with evidence that there was reasonable cause to suspect that Mr. R. was suffering from pneumoconiosis. It will be remembered that workmen employed outside the processes scheduled under the National Insurance (Industrial Injuries) Act should provide such evidence.

He was then seen by a Medical Board and the diagnosis of asbestosis was confirmed. In view of this he was relieved of his duties in the lagging party and given work in a non-dusty job. He has remained at this work ever since.

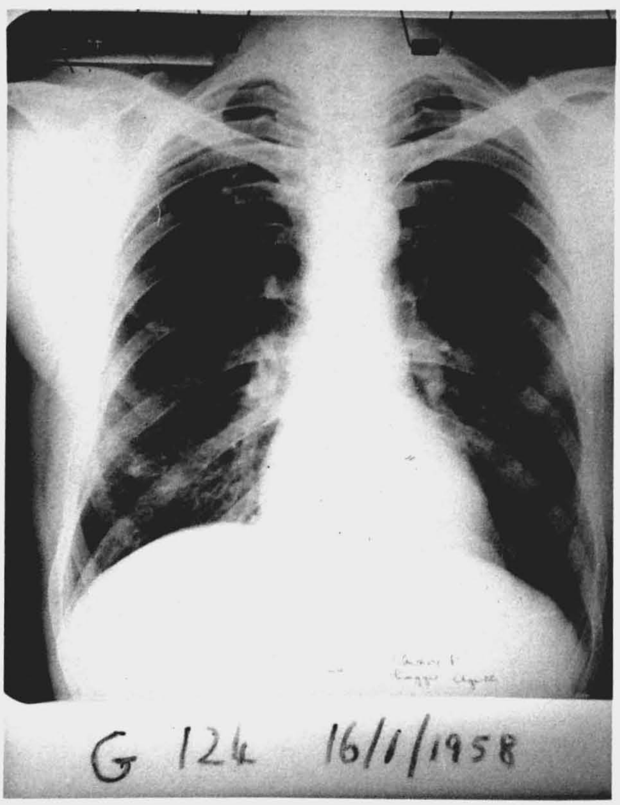
His occupational history was also typical. From 1928, when he left school, until 1930 he worked in a rope spinning factory on a rope spinning machine. From then until joining a large asbestos firm in 1932 he did a variety of odd jobs not involving asbestos. From 1932 until 1942 he was employed by a large firm of insulation engineers, doing mainly strip-lagging in Naval vessels, in many different ports. His work was said to be very dusty. From 1942 he was employed by another firm of insulation contractors on the same kind of work, and in 1945 he entered the Royal Dockyard as a lagger. He continued at this job thereafter, apart from 1949-50 when he was doing similar work in power stations, and was promoted to Chargeman of laggers in 1954.

The disposal of cases of pneumoconiosis when they occur or the cases of serious chronic pulmonary disease presents few problems, since removal from dusty jobs is clearly indicated. But in any routine radiographic survey there must be an occasional "pick-up" which requires investigation, possibly over a long period, and it is this type of case which may prove perplexing. Obviously it is not deirable to take a man away from his job unnecessarily.

Between 1955 and 1958 six cases were found which fell into this "difficult" category. 4 were cases in which the radiologist was unable to exclude asbestosis as a cause of the radiological appearances, 1 was a case of bronchitis and 1 was difficult to classify. Definite diagnoses of asbestosis were not confirmed by a visiting member of the Pneumoconiosis Medical Board, but all the men concerned are being kept under close observation. The situation was complicated by the fact that all the men had a long history of exposure to asbestos dust, Chest X-Rays relevent to the case of Mr. G..



(1) Film taken in 1955 showing the patch of calcification in the right lower zone.



(2) The 1958 film. Note the early nodular shadowing most obvious in the left middle zone.

3 had histories of previous pulmonary disease, one had clubbed fingers, and one had pernicious anaemia.

The case of Mr. G. is a typical "difficult" case from the Industrial Medical Officer's point of view, and is summarised hereunder.

Mr. G. Aged 56 years. Lagger.

Duration of exposure to asbestos dust. - 9 years.

In 1955 Mr. G's chest X-Ray (opposite) showed a shadow in the right lower zone which was diagnosed at the Chest Clinic at a later date as a patch of calcification. There were no abnormal clinical signs. A film taken in January 1958 showed some early nodular shadowing, especially in the left mid zone, suggestive of early asbestosis. The films were shown to a member of the Pneumoconiosis Medical Board who was visiting the Dockyard, but he did not think Mr. G. had asbestosis.

A short time later, Mr. G. visited his own doctor because he had a persistent cough following a cold. He was referred to the local Hospital for a Chest X-Ray and the Radiologist diagnosed asbestosis. On hearing of this diagnosis, the Senior Medical Officer advised Mr. G. to apply to the local office of the Ministry of Pensions and National Insurance for a Medical Board.

In due course he was again X-Rayed, this time at the request of the Pneumoconiosis Panel, and he was then examined by the Board. A definite diagnosis of asbestosis was not made.

Mr. G. had no significant exposure to asbestos dust prior to joining the Dockyard in 1948, and apart from a productive winter cough associated with slight wheezing, he had no abnormal symptoms. On examination, the only physical abnormality was the presence of a few "asbestos corns" on the fingers.

This case has been presented as an example of the type of problem which frequently arises. It may also serve to illustrate the difficulty of diagnosing asbestosis in spite of the allegedly characteristic X-Ray changes present in the established cases of the disease.

V.

SOME RELEVANT LEGISLATION.

Apart from the general regulations regarding the health, safety and welfare of factory workers laid down in the 1937 Factory Act, the only legislation dealing especially with the prevention of asbestosis is contained in the Asbestos Industry Regulations, 1931. The regulations deal particularly with the asbestos manufacturing industry, and embodies many of the recommendations made by Merewether and Price in their 1930 report.

Part 1 of the Regulations deals with the duties of Factory Occupiers and Part II with those of persons employed. It would be tedious to quote the full text of the publication and it will be assumed that a copy is available for reference. Briefly, however, the instructions relate to the suppression of dust by various methods such as enclosure of asbestos handling machinery, and the efficient damping of benches, floors and certain materials used in making asbestos mattresses. Adequate local exhaust ventilation must be provided as well as a satisfactory standard of general ventilation of workrooms. There are also sections dealing with the cleaning of machinery and with the storage and handling of raw asbestos.

Section 10 requires that suitable breathing apparatus be supplied for the use of certain employees. A breathing apparatus is defined as: (1) A helmet or facepiece with necessary connections by means of which a person using it breathes air free from dust, or (2) Any other approved apparatus. In some cases, overalls and head coverings must also be supplied. Young persons may not be employed in making asbestos mattresses, the important section from the Dockyard point of view, or in certain other processes. Part II directs employees in the processes to make proper use of the appliances provided for their protection and to pay due regard to the regulations made.

Medical Arrangements and Compensation.

The Asbestos Industry Regulations, 1931, made no provision for the medical examination of asbestos workers. Under the Silicosis and Asbestosis (Medical Arrangements) Scheme of 1931, however, initial and periodic examination of certain categories of asbestos workers was ordered. This statute embodied many of the recommendations made in 1929 by the Silicosis (Medical Arrangements) Committee.

Only workers in certain prescribed occupations were covered by the scheme. For those that were, the medical examinations were carried out by full-time

Officers of the Silicosis Medical Board, which had been set up under the provisions of the Refractory Industries (Silicosis) Scheme, 1925. If a case of asbestosis was found the patient became eligible for compensation under the Workmens Compensation Acts. This system continued until the National Insurance (Industrial Injuries) Act, 1946, came into operation on the 5th July 1948.

After the appointed day, employers, employees and the Exchequer paid contributions to a central insurance fund from which compensation for industrial injuries would be paid. The scheme only covered workers employed on of after the appointed day. and other workers remained covered by the Workmens Compensation Act, and schemes made thereunder. Since there were usually time limits to these schemes - generally five years or less, they would ultimately become defunct.

Certain diseases which were due to some definite industrial hazard were included in the scheme under the title of Prescribed Diseases. Asbestosis is one of these Prescribed Diseases, and sufferers from it may qualify for all the benefits and allowances available under the scheme in the same way as a worker injured during the course of his employment. Disablement benefits under the new Act are assessable on a percentage basis related to a prescribed flat rate - a change from the old scheme where compensation was based on actual loss of earnings. Also taken into account are, not only the actual handicap of the disease, but the loss of faculty in the physical and mental spheres which may affect the patient's ability to enjoy life, as compared with a person of similar age and status. Other concomitant diseases which may aggravate the disability may also be taken into account when assessing the amount of benefit. These are all important innovations from the Asbestosis patient's point of view.

The principle of prescribing certain occupations to be covered by the scheme was retained, and those covered are:-

Any occupation involving:-

(a) The working or handling of asbestos or any admixture of asbestos;

(b) The manufacture or repair of asbestos textiles or other articles containing or composed of asbestos;

(c) The cleaning of any machinery or plant used in any of the foregoing operations and of any chambers, fixtures and appliances, for the collection of asbestos dust;

(d) Substantial exposure to the dust arising from any of the foregoing operations.

As has been previously stated, only men in Portsmouth Dockyard who are recognised as being covered by this scheme are the mattress-shop workers.

All asbestos workers who are employed in the prescribed occupations have initial and thereafter annual examinations by a member of the Pneumoconiosis Medical Panel. The Panel was brought into the National Insurance Scheme by the simple expedient of transferring it from the Ministry of Labour and National Service to the Ministry of Pensions and National Insurance.

If a case of asbestosis is found by the examining Medical Officer, the patient is advised to claim disablement benefit. The amount of benefit paid is decided by a Pneumoconiosis Medical Board consisting of two members of the Panel. A similar Board also hears appeals against decisions made by the examining Medical Officers. The Board has power to suspend patients from a hazardous job if it is considered absolutely necessary.

Other workers, not employed in scheduled occupations, may claim benefit under the scheme if they are able to satisfy first the Local Officer of the Ministry of Pensions and National Insurance, and then the Pneumoconiosis Medical Board, that they are suffering from asbestosis. Such a case was that of Mr. R. quoted elsewhere in this paper. If such a case were "picked up", then he should be advised to apply to the Local Pensions Office for disablement benefit. The Local Officer of this Ministry would then ask him to produce evidence to suggest that the claimant might reasonably be supposed to have asbestosis.

This evidence may be supplied by the Industrial Medical Officer, Chest Physician or some other doctor and in due ocurse the patient will be seen by the Pneumoconiosis Medical Board.

There is, therefore, little hardship caused by retaining the scheduled occupations system, and probably the system saves the Boards from having to deal with a spate of claims, many of them frivolous.

Certain persons were not covered by the Workmens Compensations Act or the National Insurance (Industrial Injuries) Act, and for these people special arrangements have been made. For those who were totally disabled by or had died from pneumoconiosis, but who were unable to claim under either Act, the Pneumoconiosis and Byssinosis Benefit Act, 1951, was passed. This Act permitted benefit to be paid from the National Insurance Fund to such persons. The details were given in the Pneumoconiosis and Byssinosis Benefits Scheme, 1952, which is administered by an independent Benefit Board appointed by the Minister of Pensions and National Insurance. The Scheme was amended in 1954 to include persons who were only partly disabled by pneumoconiosis.

VI.

Some Notes on the Work Done by Asbestos Workers in Portsmouth Dockyard and the Materials They Use.

It should be pointed out straight away that asbestos technology is a subject of some complexity, as was soon found out during the collection of material for this study. Obviously, therefore, it has not been possible to include a great amount of technical detail but it is hoped that enough will be said to enable the problem of preventing asbestosis in Dockyards to be seen more clearly.

The Sprayed Asbestos Process.

Two well known proprietary names for this process are the "Limpet Asbestos process", used by Newall's Insulation Co. Ltd., and the "Silbestos" process marketed by Dick's Asbestos and Insulation Co. Ltd. Both involve the spraying of specially prepared asbestos fibre, usually of the blue variety, on to surfaces it is desired to insulate. Apart from having good thermal and sound insulating properties, the process also renders the treated surfaces fire resistant.

Blue asbestos is used because the fibres are less "spiky" than those of amosite, it is the lightest in weight and it has the highest capillarity. The binding materials used in the felt (the layer of asbestos fibre) are usually emulsions, hydraulic cements, or mixtures of the two. The more usual water soluble binders, such as sodium silicate, would be unsuitable as continued exposure to condensation would leach them out. This condensation is an important factor in the thermal insulation of compartments. Air at compartment temperature will enter the substance of the insulation and some of the moisture it contains will condense on the cooler surfaces within the felt and on the surface outside the lagging. This condensed moisture is drawn up the asbestos fibres by capillarity and is evaporated back into the compartment, thus preventing saturation of the insulation with water, and corrosion of the underlying metal.

In operation a spray gun is used. The blue asbestos fibre is discharged from the main nozzle of the gun and is intersected by a spray of water discharging simultaneously. A thorough intermingling of these ingredients takes place before striking the surface to be treated. Adhesion to the surface is ensured by pre-treating it with a "primer", usually a high melting point asphalt emulsion, bitumen or P.V.C., according to the nature of the surface. Usually it is possible to build up the thickness of the insulation required without the need for a supporting framework unless a hard setting finish is applied.

In ships it is usual to apply such a hard setting cement over the layer of asbestos fibre. The cement is composed of chrysotile fibre, with alumina cement as a filler, the amount of filler used being decided by the hardness and density of the finishing coat required. It is trowelled on over the layer of sprayed asbestos and, because of its weight, it is usual to reinforce the lagging with wire netting or expanded metal before the application of cement. Sometimes a P.V.C. finish is applied instead of an asbestos cement.

The advantage claimed for this form of insulation is that intimate contact may be obtained between the lagging and the surface to which it is applied. This eliminates pockets in which condensation may accumulate, and thus helps to prevent corrosion. Like other forms of asbestos lagging, it is chemically inert, rot-proof, vermin-proof, reasonably light in weight and will withstand vibration. Waste due to cutting panels to shape is eliminated and it is a good insulator for heat (limiting temperature 850°F) and sound.

As has been stated earlier, less use is now being made of this process in Portsmouth Dockyard, and most of the work done consists of repairing existing sprayed asbestos lagging.

From the medical point of view an obvious hazard exists, even though the fibre iswet during the actual

The workers at risk of contracting asbestosis

Two photographs showing a " Limpet " sprayer at work.

spraying. Stray fibres may dry out and be inhaled by unprotected persons. Respirators should therefore be worn by all personnel involved in this process, and the mask should be of a type approved by the Chief Inspector of Factories for the purpose. The man seen in the photograph opposite is wearing a Siebe-Gorman Mark IV respirator, which is an approved type.

A bigger hazard exists during the stripping down of old lagging. Obviously the dry lagging gives off a great deal of dust during stripping operations and measures to control it should include efficient ventilation, provision of respirators for all workpeople involved in the process, and the efficient damping of the insulation before stripping. An authority on this subject has suggested that pre-damping of the material with as little as 3% of its weight of water would reduce the dust to acceptable limits. Efficient pre-damping may be difficult technically if a hard setting surface has been applied to the lagging, but even if it were done and the dust reduced, no level of asbestos dust above zero should be considered low enough to permit working without all the usual safeguards.

Other Forms of Lagging.

For the sake of convenience, these have been divided into four groups, namely those types of lagging composed

The manufacture of asbestos insulating mattresses.

(1) "Marking off."

(2) Sewing up the mattress covers.

mainly of asbestos in (1) textile form, (2) rope, (3) pre-formed pipe sections, slabs, blocks or mouldings or (4) plastic composition.

(1) Textiles.

Most asbestos cloth is made from white asbestos (chrysotile) because its fineness of texture and high magnesia content make it ideal for spinning. For special purposes where, for instance, maximum resistance to chemical action is required blue asbestos cloth may be made.

The majority of asbestos cloth used in lagging work is made into mattress covers which are then stuffed with asbestos flock. A workshop for the manufacture of such mattresses exists in Portsmouth Dockyard and the workers employed there are in a scheduled occupation under the National Insurance (Industrial Injuries) Act, 1946. The premises are subject to the conditions laid down in the Asbestos Industries Regulations, 1931.

Theoretically the making of asbestos mattresses is a simple matter. Having worked out the size and shape of mattress required for a particular job, a pattern is prepared, the pieces are marked off on a length of asbestos cloth and then cut out. The pieces are then sewn together with asbestos thread, or thread composed of asbestos plus cotton or wire. The cover thus made is then stuffed with asbestos flock - usually

The manufacture of asbestos insulating mattresses.

(3) Filling the mattresses with amosite asbestos fibre.

(4) Final sewing up.

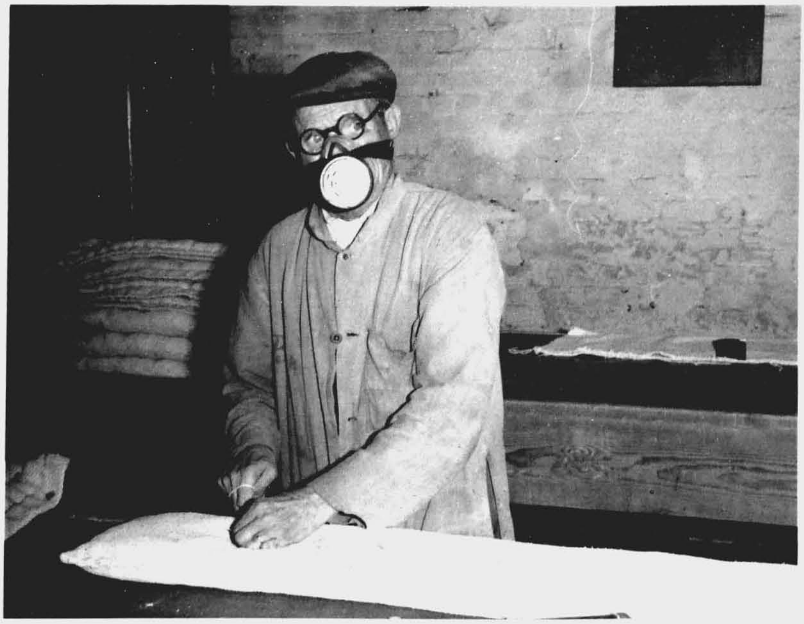
pure amosite asbestos, the flock being kept in a cabinet supplied with exhaust ventilation. After final sewing up, the last processes are the levelling, beating and stabbing of the mattresses. Levelling and beating are designed to distribute the filling evenly in the mattress, and stabbing consists of stitching the mattress at selected points, or sewing buttons on to it, to prevent the stuffing from shifting.

The only filling material for mattresses used in Portsmouth Dockyard is pure amosite asbestos fibre, but magnesia, consisting of 85% magnesia and 15% amosite, may be used. Other filling materials available consist of amosite plus diatomaceous earth. The limiting temperature of the material rises with increasing proportions of the earth.

Some photographs of men making asbestos mattresses are appended. Since they were taken many improvements have been made to the workroom, and these will be mentioned later. The hazard is obvious as all the processes are dusty, particularly the filling, beating levelling and stabbing. Clearly the materials should be effectively damped and the workers provided with approved respirators. Exhaust ventilation cowls have now been fitted over the benches

Asbestos cloth may also be used to "jacket" other types of lagging applied to pipes, etc. Asbestos tape

The manufacture of asbestos insulating mattresses



(5) The "stabbing" process.

of various widths may also be used alone as a thermal insulator, or in conjunction with other forms of lagging. A coat of weatherproofing compound may be applied to the cloth to protect it from damage.

(2) Asbestos Ropes and Asbestos-Fibre-Filled Rope Lagging.

Asbestos used in this form may be very useful for insulating pipes, or apparatus of a shape difficult to insulate by other means.

Ropes may be made by either of two methods. Firstly, two or more strands of asbestos wicking may be twisted tightly together to form a rope of the required thickness. Alternatively, the rope may be made of several braided jackets, one overlaying the other until the required diameter is built up.

In thermal insulation work it is more usual to use asbestos-fibre-filled rope, which is composed of a central core of freshly carded asbestos fibre, contained within a braided asbestos envelope. Amosite, chrysotile or blue fibre may be used in the making of rope.

The hazard in using asbestos rope lagging is the fine dust which arises when the free end of the rope "flicks" round the pipe during application process. It is interesting to note that many laggers dislike applying asbestos-fibre-filled rope lagging more than any other sort of asbestos insulating material.

(3) Asbestos Pre-formed Pipe Sections, Slabs, Blocks and Moulding.

For a wide variety of insulation work it is convenient to have the lagging material in a form which permits quick and easy application to the surfaces to be insulated. The manufacturers therefore supply a large range of materials to meet this demand.

Pre-formed pipe sections are made in a number of thicknesses and diameters. They are manufactured as pipes, but are sawn longitudinally to give two half cylinders. These are placed round the pipe to be insulated and secured with metal bands. Their outer surface may be covered with calico, canvas or asbestos cloth. Mouldings, somewhat similar to muffs, are made to fit valve boxes, bends and similar structures. Slabs and blocks are available in many different sizes and thicknesses.

The composition of all the lagging materials is basically the same. When pure asbestos is used, amosite is usually the fibre employed, but blue fibre may be used in special situations. Only pure asbestos is used in Portsmouth Dockyard. Other materials available are made of magnesia (85% magnesia, 15% asbestos) or calcium silicate plus asbestos, known commercially as "Newtherm".

Pure asbestos products include the Caposite and

Caposil ranges marketed by the Cape Asbestos Co. Ltd., the "Antithermic" range produced by Dick's Asbestos and Insulation Co, Ltd., and those made by Newall's Insulation Co. Ltd. A small percentage of sodium silicate is used as a binder in conjunction with the asbestos and in this form the lagging has a limiting temperature of 1000°F - suitable for most purposes. For higher temperature work, diatomaceous earth is inoorporated also, and sometimes a lime-silica bonding material. The limiting temperature rises as the proportion of diatomaceous earth increases, and may reach 1850°F. Materials having a high limiting temperature may be used to break an initially high temperature down to one within the range oflower temperature materials.

Products made from magnesia have a limiting temperature of about 625°F, but by adding diatomaceous earth this may be increased to 1625°F. Newall's Nicosil and Newtempheit ranges are magnesia plus diatomaceous earth. Newtherm calcium silicate insulation has a limiting temperature of 1400°F. For lower temperature work - up to 650°F, Bell's Asbestos and Engineering Ltd. supply pre-formed sections composed of corrugated asbestos paper interleaved with aluminium foil.

From the medical point of view, there is much to be said for pre-formed sections, as the dust hazard is, on the face of it, low. There is, however, considerable dust involved during the cutting to size of sections, and the physical effort involved in such cutting may well tempt the operatives to remove their respirators.

(4) Plastic Compositions.

Much of the lagging work in engine and boiler rooms would not be easy using the methods so far described, owing to the large size and irregular outlines of the surfaces to be insulated. To such surfaces asbestos, or asbestos containing lagging, may be applied in the form of a wet, plastic composition.

The plastic composition used in Portsmouth Dockyard is composed of amosite asbestos fibre and diatomaceous earth, china clay being incorporated as an adhesive. As before, the limiting temperature of the lagging is a function of its diatomaceous earth content. The Caposite and Caposil ranges of plastic compositions are widely used, the Caposil H.T. compound being effective up to 1850°F. The material is supplied for use as a powder which is mixed with water in large open tubs on the quayside. The resulting paste is then spread over the surfaces to be insulated, and allowed to dry. If desired, a super-coating of hard setting asbestos cement is applied which may be decorated as required.

Magnesia is also available as a plastic composition.

It has been claimed that it is easier to mould magnesia to fine limits than the pure asbestos composition, but pure amosite is preferred by Admiralty Engineers. Magnesia insulation may still be found, however, in older ships and installations.

The dust hazard is minimised when applying composition since it is wet. On the other hand, if a job takes some days to complete then some of the material will have dried out before the rest is applied, and so some dust may be present. The main hazard, however, is the great amount of dust evolved during the stripping down of old lagging. Stripping magnesia insulation is a particularly dusty operation but the dust is not entirely composed of asbestos.

Miscellaneous.

A number of other products are also available which are used in lesser quantities, such as asbestos and silica boards, and asbestos felt. Their composition is similar to the other materials described. Asbestos millboard differs very slightly, however, in that it contains asbestos, china clay and starch. This formula permits the board to be moulded to any desired shape after wetting with water.

VII.

THE USE OF ASBESTOS IN CONNECTION WITH HABITABILITY AND SAFETY IN SHIPS.

The efficiency of asbestos lagging materials is due to their ability to hold within their mass a large amount of air. If the fibre is compressed, a hard board is produced which may be used as a panelling material for lining the hulls, deckheads and bulkheads of ships. Obviously, such panelling will not have thermal and sound insulating properties to the same degree as fiberised asbestos, but this deficiency may be rectified by backing the panels with amosite asbestos flock or slab, mineral wool, fibre-glass, or magnesia. Sound insulation properties may be further enhanced by drilling large numbers of small holes in the panelling. These permit sound waves to pass into the backing material, where they are readily absorbed.

Basically, asbestos panelling consists of compressed amosite asbestos fibre with a lime-silica bond. The surface may be veneered, covered with plastic or aluminium, or painted in any desired colour. Newall's Paxmarine System, and the Marinite Products made by the Cape Asbestos Company are available in forms to suit all purposes.

Large quantities of panelling are used to help control the interior environment of a ship. Lining the hull will help to keep the temperature stable, and lagging deck-heads and partitions will help to prevent dissemination of noise throughout the vessel. The sprayed asbestos techniques have been extensively used for these purposes, but are now used much less in Portsmouth Dockyard because such effective substitutes are now available.

Over and above all their other properties, the incombustibility of these products is perhaps their most important attribute, since a fire at sea, be it in a warship or merchantman, is a major disaster. The International Convention For Safety of Life at Sea, defines an incombustible material as one which will neither burn nor give off inflammable vapour in sufficient quantity to light a pilot flame when heated to approximately 1382°F (or 750°C). Asbestos panelling materials conform to this standard, and when used in place of inflammable materials for lining compartments protection is in two ways. Firstly, it eliminates inflammable structure, and thus deprives the fire of the fuel necessary to keep it going, and secondly, by bounding the space with incombustible material the fire is contained until it burns itself out or is put out.

The problem from the medical point of view arises from the fact that an asbestos containing dust is evolved when the panels are sawn to shape or drilled, and such operations may well take place in confined spaces. Also the manipulation of these panels is normally the work of shipwrights who may be unaware of the hazard, unlike laggers who are usually keenly aware of it. So far the problem has not assumed major proportions in Portsmouth Dockyard, but if the use of these materials becomes more widespread in Naval vessels then it maydo so. Perhaps the fitting of asbestos panelling should be limited to men suitably protected against dust and aware of the hazard involved.

VIII.

THE PREVENTION OF ASBESTOSIS.

In this section it is proposed to deal with the prevention problem in two parts; as it affects, firstly, the workers in workshops, and secondly, those at work in ships and installations. Some aspects of the problem are, however, common to both groups and will be discussed first.

Obviously it is necessary to employ only men who are reasonably fit, from the pulmonary aspect at least, on the job involving possible exposure to a fibrogenic dust. Pre-employment medical examination is therefore essential, and the examination should include a full-plate Chest X-Ray. Annual X-Rays of chest should be taken thereafter, and also full physical examination. The medical examination may even be done every six months if the exposure to dust is intense.

Having obtained a fit population of asbestos workers, measures must be taken to prevent them inhaling asbestos dust arising from their work. Attention should be paid to the following points:-

1. The substitution of non-toxic material wherever possible.
2. The automatic manufacture or performance of dangerous processes if practicable.

3. The removal of toxic material at source by means of locally applied exhaust ventilation.
4. The suppression of dust by damping, etc.
5. The provision of a good standard of general ventilation.
6. The maintenance of a high standard of general ventilation in workplaces.
7. The provision of adequate and efficient protective equipment, such as respirators and overalls.
8. The education of the workmen with regard to the hazards of their job and the proper use of protective equipment.

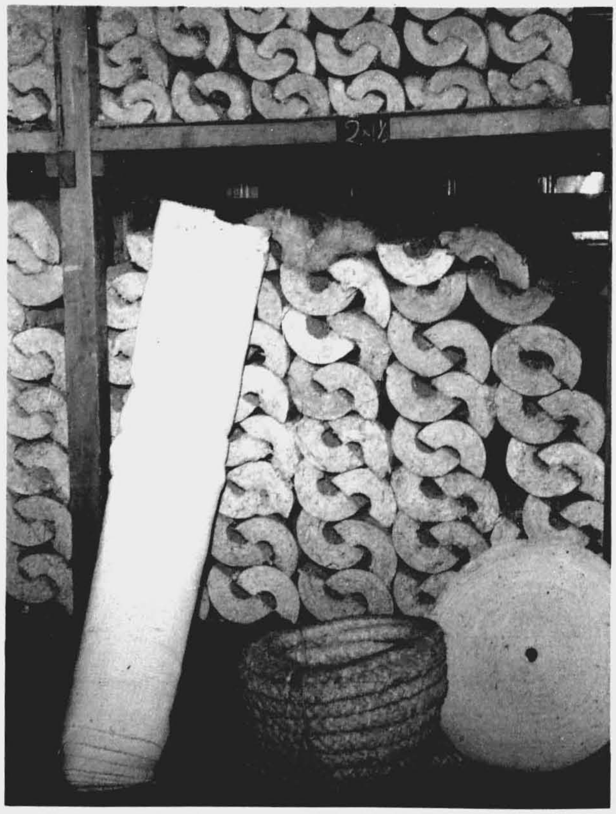
<u>Workshop Workers</u>.

In Portsmouth Dockyard the employees covered by this heading are those employed in the mattress manufacturing shop, and a small number of men working in the asbestos storehouse.

The Asbestos Industry Regulations, 1931, lay down definite standards for mattress-making workshops, and the one in Portsmouth Dockyard conforms to these regulations. Factory Inspectors regularly visit the mattress shop in order to see that the regulations are being properly carried out.

Generally speaking, codes of regulations lay down a minimum standard. In Portsmouth Dockyard, several

The Prevention of Asbestosis



Photograph showing a small corner of the asbestos store in H.M.Dockyard, Portsmouth. A roll of white asbestos cloth, a coil of asbestos rope, a coil of asbestos tape and racks containing pre-formed asbestos pipe sections may be seen.

improvements have recently been made to the asbestos mattress shop which are worthy of mention. The walls of the shop have been rendered smooth with an impervious material which makes the cleaning of them, either by vacuum cleaner or washing, much easier and more efficient. Hoods, made of perspex, have been erected over the sewing benches. They are provided with exhaust ventilation and, being transparent, the worker is able to see his work through the hood. Other improvements have been made which include more efficient exhaust ventilation at the hoppers down which asbestos is fed to the filling chambers, and the filling chambers themselves have had a more dust-tight opening made. Damping of covers, benches and floors is done by means of hand sprays, and even greater efforts are being made to encourage the workers to use them.

Considerable amounts of asbestos are kept in the asbestos store, and a photograph of a small section of it is appended. There must be a significant dust hazard within this store and respirators should be used by the staff. Actually, dust caused by sliding pre-formed pipe sections in and out of racks could be completely avoided, since manufacturers now supply sections ~~of~~ in expendable cardboard cartons. The sections could remain in the cartons until required for use, and issued out to the users in the container.

"Outside" Workers.

These workers face an asbestosis hazard which is more difficult to control. The work they do is often very dusty indeed, and is often done in the confined spaces of ships. Stripping down old lagging is the most dusty of their jobs. Obviously it is not possible to fit fixed exhaust hoods, etc. and owing to the large amount of dust involved no completely effective portable exhaust ventilation system is available.

The men working in ships are provided with respirators of the "Microfilter" type and overalls. Wherever possible the lagging is pre-damped before they strip it, but this is not an entirely satisfactory procedure as the hard-setting cement applied to the lagging renders it more or less waterproof, at least to water applied in reasonable quantities. Industrial vacuum cleaners and double-bottom pumps have not been very satisfactory in dealing with the dust. Obviously other workmen, apart from the laggers, may be exposed to the dust as well.

Probably this is a job where personal protection of the worker is the most useful preventive measure. In order to reduce the hazard further, the work could be done at times when other workers are not in the same

Approved Dust Respirators

Microfilter.
(Siebe, Gorman & Co. Ltd..)

The Mark IV dust respirator.
(Siebe, Gorman & Co. Ltd.).

compartment, for example during the night. Double-bottom pumps fitted with flexible hose could be provided to assist dust removal, and all the plating, ledges and so on, should be cleaned down with a vacuum cleaner after completion of the work.

Respirators.

A section has been devoted to the subject of respirators because the provision of an efficient respirator is the most important single preventive measure which can be used to protect laggers. Indeed, if the respirator were perfect and the worker wore it all the time, asbestosis would not exist. Unfortunately, neither the respirator nor the worker are perfect in this respect.

The Chief Inspector of Factories "approves" certain respirators for certain jobs, and workers covered by the Asbestos Industry Regulations, 1931, must be provided with a respirator which is so approved. An approved dust respirator must:-

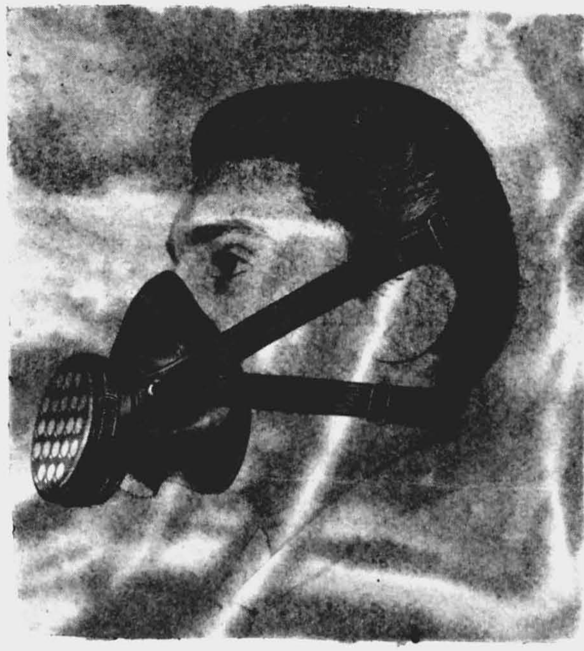
(1) Fit the face closely.

(2) The filter unit must effectively prevent the passage of dust whilst offering low resistance to breathing.

(3) Must be generally comfortable and not obstruct vision - particularly in a downward direction.

(4) Must be easy to clean and maintain.

Approved Dust Respirators



The Mark VIII respirator.
(Siebe, Gorman & Co. Ltd.).

The Drager respirator.
(Normalair Ltd.).

(5) Must have easily interchangeable filter units.

Four approved designs are the Microfilter, Siebe-Gorman Mark IV, Siebe-Gorman Mark VIII and theDräger respirator. Siebe-Gorman & Co. Ltd. state that typical efficiency figures for the three models made by them are:- Mark VIII 99.5%, Microfilter 98%, and the Mark IV 96%. Efficiency figures for the Dräger are not available. Photographs of these masks are appended hereto, and any further information on these, and other non-approved masks may be obtained from the Industrial Health and Safety Centre, 97 Horseferry Road, London, S.W.1

In Portsmouth Dockyard Microfilter respirators are the ones most commonly used by the laggers. Some workers, however, wear the Siebe-Gorman Mark IV. The introduction of the Siebe-Gorman Mark VIII respirator is a recent event, and probably this apparatus will be adopted in due course.

Substitution of Non-Toxic Materials.

There is no substitute for asbestos which is its equal in all respects. In some situations, however, synthetic products may be used instead of asbestos. Fiberised glass wool, and rock or slag wools contain no asbestos and may be useful substitutes. Rock wool, such as the "Rocksil" manufactured by the Cape Asbestos Co., is made from dolomite and fire-clay. The materials are allowed to pass in a molten form through tiny holes, are then caught in jets of high pressure steam and form into long fibres of uniform diameter. Fibreglass is made in a similar way but the raw material used in glass is the form of small marbles, which are melted prior to the fiberisation process.

"Rocksil" and similar substances have a high limiting temperature when used in the form of a wool - up to 1400°F. The fibre length is about two inches, sufficient to produce a good "felting" effect without bonding materials, and to be resilient. As one may expect it is non-corrosive to ferrous and non-ferrous metals, resists attack by chemical agents, is vermin-proof and fire-resistant. Pre-formed sections and slabs are made from the material, and in these resins are used as bonding agents. The limiting temperature of the resulting product is determined by that of the resin used, 600°F being the maximum.

Here then is a substitute for asbestos suitable for a wide variety of situations in which the unique properties of asbestos are not required. It could be used for insulating deckheads and bulkheads, engine and boiler room casings, trunkings, etc. It is also useful for cold insulation. Hard setting cement may be applied over the insulation or it may be faced with an asbestos panelling of some sort.

Fibreglass and rock wool are not fibrogenic, but cases of dermatitis have been reported which were probably caused by sensitisation to the resin used as a bonding agent.

IX.

DISCUSSION.

It is hoped that the information contained in this article has established the existence of an asbestosis hazard amongst certain workers in the ship-building and ship-repairing industries. In fact, the same hazard is faced by laggers in many other industries as well.

In the annual report of the Chief Inspector of Factories, 1956, the problem of laggers is mentioned. Under the heading "Asbestos Industry Regulations, 1931", the Chief Inspector reviews the present situation with regard to the substitution of non-fibrogenic substances for asbestos. He notes that fibreglass and dolomite wool are used for some insulation purposes in ships, but asbestos is still the most widely used insulating material. Regarding laggers, he says:-

"One very hazardous process to which the Regulations do not always apply is the removal of old insulating lagging. The handling of this very dry and dusty material presents a serious health hazard, which is all the more serious because the work is often done in confined spaces. Much of this work is done in premises not subject to the Factories Acts, and in any case the operation does not take long. The persons who do it are, however, regularly engaged on it, and are therefore continually exposed to risk."

Since no completely satisfactory substitute for asbestos is known, it would be ludicrous to suggest eliminating asbestos from the industries. Indeed, asbestos plays a most valuable part in the maintenance of health in seamen by assisting in the control of their environmental comfort. A state of peaceful co-existence must be made to exist between man and asbestos. Conditions in factories are not bad and have been improved, owing to increasing knowledge of the hazard of asbestosis, but cases of the disease still occur.

Unfortunately, it is not possible to assess the size of the problem of preventing asbestosis in laggers. This is because lagging is not a scheduled occupation, and therefore the total number of laggers is not known. In terms of cases of asbestosis the problem is not very great. Up to 1956, 271 deaths from asbestosis had been investigated, and in the years 1953, 1954 and 1955, there were respectively 22, 31 and 48 new cases of asbestosis diagnosed by the Pneumoconiosis Medical Boards. It is not known how many of these cases were employed as laggers. But however small the numbers may appear to be, the problem of prevention still exists.

Owing to the nature of their work, it would not be possible to lay down a strict code of regulations to cover laggers in the same way as workers in the Asbestos Manufacturing Industry were covered by the Asbestos Industry Regulations, 1931. But a simplified code covering such things as protective clothing, ventilation and the pre-damping of insulation prior to stripping, could be drawn up. Lagging could also be made a scheduled occupation and thus entitle the laggers to initial and periodic medical examination. Whether the Pneumoconiosis Panels are large enough to deal with the laggers in addition to their existing commitments is an open point, but this problem could easily be solved. Either the Panels could be enlarged to cope with the extra work, or the Appointed Factory Doctors could be invited to do the physical examinations involved and Regional Hospital Board Radiologists the X-Ray examinations. Alternatively, the Chest Physicians in charge of local Chest Clinics could be asked to do the work.

It is neither suggested nor implied that the absence of statutory obligation to provide these services for laggers means that nothing at all is being done for them. In most factories where laggers are employed, such as H.M.Dockyard, Portsmouth, all reasonable precautions are being taken to protect their health. It would, however, prevent "backsliding" on the part of less conscientious employers, and would cause schemes to improve the working

ASBESTOS/FOUNDRY WORKERS

Name	Occupational History	Medical History
No.		
Date of Birth		
Grade		
Date of Entry		
Date started in Foundry		
Name of Doctor		

Specimen Medical Record Card for Asbestos Workers.

conditions of laggers to be given a higher priority, if such measures were to be given statutory support.

The problem is not made easier by the fact that there is considerable "drifting" of laggers from one job to another. Lagging is not a trade in the usual meaning of the word, and therefore laggers are less likely to be employed as such all their working lives. The keeping of some kind of personal health record for each lagger, which, at the request of the lagger, could be passed on to the Medical Officer of his subsequent employers, would seem to be highly desirable. Such records are kept at Portsmouth Dockyard, and a specimen record card is appended. This card, along with copies of each X-Ray or other report received, is kept in a stout envelope, and filed in the Dockyard Surgery. The Pneumoconiosis Medical Board do, of course, keep records of all the examinations they undertake in respect of workers in scheduled occupations.

Specimen Medical Record Card for Asbestos Workers
(Reverse).

Date						
Complaints cough sputum dyspnoea wheezing pain in chest						
Expansion						
Examination chest, etc.						
Skin						
X-Ray						
Weight—clothed						
Signature						

X.

SUMMARY AND ACKNOWLEDGMENTS.

Summary.

The various uses of asbestos in the ship-building and ship-repairing industries are briefly reviewed, with particular reference to the work of the laggers in Portsmouth Dockyard. Short sections on the nature of asbestos and asbestosis are included.

Measures which are, or may be, taken to prevent asbestosis in these industries are discussed, and attention drawn to the inadequacy of legislation in this field. The problem should be given consideration since the amount of lagging work done is likely to increase in the future.

Acknowledgments.

Invaluable help in the collection of material for this paper has been received from a number of sources. In particular it is desired to thank the Medical Director General of the Navy, the Admiral Superintendant and the Senior Medical Officer of H.M.Dockyard, Portsmouth, for permission to present this dissertation. Also, the numerous members of the Cape Asbestos Co. Ltd., Dick's Asbestos and Insulation Co. Ltd., Newall's Insulation Co.Ltd., British Belting & Asbestos Ltd., Bell's Asbestos and Engineering Ltd., and the Universal Asbestos Manufacturing Co. Ltd., who have provided information on their products. For other information, thanks are offered to members of the Pneumoconiosis Medical Panel, the Factory Inspectors of the Industrial Health and Safety Centre, and the authors of all the books and papers to which recourse has been made. And lastly, but by no means least, to all the asbestos workers in Portsmouth Dockyard, whose cheerful co-operation made the compilation of the practical part of this dissertation such an interesting and enjoyable task, the author's gratitude is expressed.

BIBLIOGRAPHY.

CARROLL-PORCZYNSKI, C.Z. Asbestos. The Textile Institute, 1956.

COOKE, W. E. (1924), Brit. Med.J.,ii,147.

Departmental Committee on Compensation for Industrial Diseases (1907) Report. H.M.S.O.(Cd.3495), London.

Departmental Committee appointed by the Secretary of State to advise as to the Medical Arrangements which could be made for the diagnosis of Silicosis (1929) Report. H.M.S.O., London.

DOLL, R., 1955, Brit. J. Industr. Med., 12, 81.

GLOYNE, S.R., in Silicosis and Asbestosis, Ed.A.J.Lanza Oxford University Press, London, 1938, P.239.

HOLT, P.F., Pneumoconiosis. Edward Arnold (Publishers) Ltd., 1957.

HUNTER, D., The Diseases of Occupations. English Universities Press Ltd., 1957.

KING, E.J., CLEGG, J.D., and RAE, V.M., (1946), Thorax, 1, 188.

LANZA, A.J., Asbestosis - a Paper read before the fourth Conference of the McIntyre Foundation on Silicosis held in Noranda, Quebec, January 1952.

McDONALD, S., (1927) Brit.Med.J., 11, 1025.

MEIKLEJOHN, A., (1954) Brit.J. Industr. Med. 11, 198.

MEREWETHER, E.R.A., Industrial Medicine and Hygeine, Vol.3, Butterworth & Co.(Publishers) Ltd., 1956.

\- - - - (1947) Annual Report of the Chief Inspector of Factories. H.M.S.O., London.

MEREWETHER, E.R.A., and PRICE, C.W. (1930) Report on the effects of Asbestos on the Lungs and dust suppression in the Asbestos Industry. H.M.S.O., London.

Ministry of Labour and National Service. Annual Report of Chief Inspector of Factories, 1956. H,M.S.O., London.

Ministry of Pensions and National Insurance. Annual Reports, 1953-1957, H.M.S.O., London.