PULMONARY TUBERCULOSIS

in the

ROYAL NAVY,

With Special Reference to its Detection and Prevention.

A thesis for the Degree of Doctor of Medicine of the University of Glasgow

by

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May, 1913.

PULMONARY TUBERCULOSIS IN THE ROYAL NAVY, WITH SPECIAL REFERENCE TO ITS DETECTION AND PREVENTION.

Pulmonary tuberculosis is not a disease readily associated with sea life, and certainly not a disease one would expect to be common in the Royal Navy, composed as it is of picked men, leading an active, healthy life.

Sea air is supposed to be inimical to the bacillus tuberculosis, and sea voyages are frequently recommended as a cure to its ravages. In fact, the whole life and environment of the sailor would lead one to believe that pulmonary tuberculosis would be one of the least common of diseases at sea.

A mere glance at the statistics published yearly in "The Health of the Navy," however, at once proves how fallacious is such a belief. Tuberculosis, far from being a rare disease in the Navy, is one of the commonest and is responsible for more invalidings and deaths than almost any other disease.

The figures for 1911 read:

Number of cases	286, or 2.44 per 1,000.
Invalidings	237, or 2.02 per 1,000.
Deaths	38, or .32 per 1,000.

and the number of days sickness is 25,194.

This means a great loss to the Service, not only of time but also of men, many of whom are highly trained in their special branches, gunnery, torpedo, &c.

In the figures given in "The Health of the Navy" for 1911 (the last published) we find the greatest number of invalidings are due to:

1.	Diseases of the Circulatory System	329
2.	Diseases of the Nervous System	282
3.	Tuberculosis	237

while the greatest number of deaths arise from:

1.	General injuries	68
2.	Tuberculosis	38
3.	Diseases of the Circulatory System	38

Of the 286 cases of tuberculosis recorded, the lungs were affected in by far the greatest number of instances; 245 cases, or just six-sevenths of the total, being cases of pulmonary tuberculosis.

In addition to these 245 undoubted cases of pulmonary tuberculosis, there were recorded under Diseases of the Respiratory System, 63 cases of phthisis and 12 cases of haemoptysis, many of which were, I have no doubt, due to infection of the lungs by the tubercle bacillus, though it could not be actually demonstrated.

The reasons why pulmonary tuberculosis should be so common in the Navy are not difficult to find.

Sea air may be inimical to the tubercle bacillus and sea voyages may be recommended as beneficial to, or curative of consumption, but the sailor does not spend his life perpetually inhaling ozone, nor basking in the sunlight in a deck chair sheltered from the wind.

With the abolition of masts and yards and the

advent of steam much of the open air life of the sailor has gone, and most of the work in modern fighting ships is now done in confined quarters to which fresh air is only admitted through ventilating trunks, and where direct sunlight - the greatest enemy of the tubercle bacillus - never penetrates.

It is very difficult to form an opinion from the records as to the relative amount of pulmonary tuberculosisi in the Navy now and the amount in the days of sailing ships. Diseases were not as carefully classified then as now, and the term phthisis probably included many non-tubercular diseases of the lung. The figures for the five years 1856-57-58-59-60 (the first years of publication of "The Health of the Navy") read:

Phthisis and Haemoptysis.

Cases	7 per 1,000.
Invalidings	5.4 per 1,000.
Deaths	2.3 per 1,000.

These figures, allowing that a considerable proportion of cases were non-tubercular, point to pulmonary tuberculosis being even more rife then than now.

From these figures and from the fact that the disease is diagnosed in earlier stages and with more certainty than formerly, we are justified in concluding that pulmonary tuberculosis is less common in the fleet now than it used to be and that, despite the fact that sailors now lead a less open air life than they did then.

This decrease is due to the better hygienic conditions of the sailor's quarters, the better [redacted] quality of his food, both of which factors go to improve his resisting powers when exposed to infection, and to the

prompt segregation of those suspected to be suffering from this disease; also to the more careful selection of recruits on admission.

This is supported by the following statement from "The Health of the Navy," 1910. "Although there are considerable fluctuations in the amount of tuberculosis recorded annually the case ratio has, despite the more accurate classification and diagnosis evidenced by the fall in the amount of invalidings for phthisis, tended to decrease during the last few years. The decline of the disease among the general population ashore is no doubt reflected among the men recruited for the Navy, and other factors probably aiding in the decrease are the prompt removal by invaliding of possible sources of infection in the shape of definite cases of pulmonary disease, and the improvements which have been made in late years in the general environment of the sailor."

The following tables taken from "The Health of the Navy" for the five years 1907 to 1911 inclusive, give some interesting figures. In these tables pulmonary tuberculosis is not differentiated from general tuberculosis, but the total numbers of cases of each are given in the first column of table I, and there is no reason to suppose that the ratio differs in other instances.

Table I shews the large proportion of cases of pulmonary tuberculosis to general tuberculosis. It also shews that though there is considerable fluctuation of the figures for each year, the ratio per 1,000 men, of

Cases, Invalidings and Deaths, is much lower than the average for the preceding five years which I have given below.

Table II shews the number of cases and the ratio per 1,000 in the different Ranks and Ratings. In most cases the numbers are too small to give accurate ratios, but in the case of seamen, engine room ratings and marines, the figures are sufficiently large to be considered approximately correct, and contrary to expectation the ratio of cases is lowest among the engine room ratings. This bears out the statement made elsewhere that the engine rooms and stokeholds are amongst the best ventilated parts of the ship.

The high ratios noticed under Cooks and Sick Berth Staff are interesting and suggestive.

Table III shews the ratios in the different Fleets and Stations. The East Indies is always relatively high, but owing to the short commissions, which only allow a man to remain abroad for two years, this table cannot be regarded as of any value, as men can easily contract tuberculosis on one Station and not shew any signs or symptoms till after they have left it.

For the same reason it is not possible to credit any class of ship or any individual ship with a greater tendency to favour the contraction of tuberculosis than others.

Tables IV and V shew the ages and length of service respectively of Officers and Men invalided for tuberculosis. The greatest number of invalidings occur between the ages of 25 and 35, the years when a man is

in the prime of life. Table V shews too in the number of men invalided under five years service the impossibility of detecting latent or incipent tuberculosis in recruits even with the strict physical examination required by Art. 1154 of the King's Regulations.

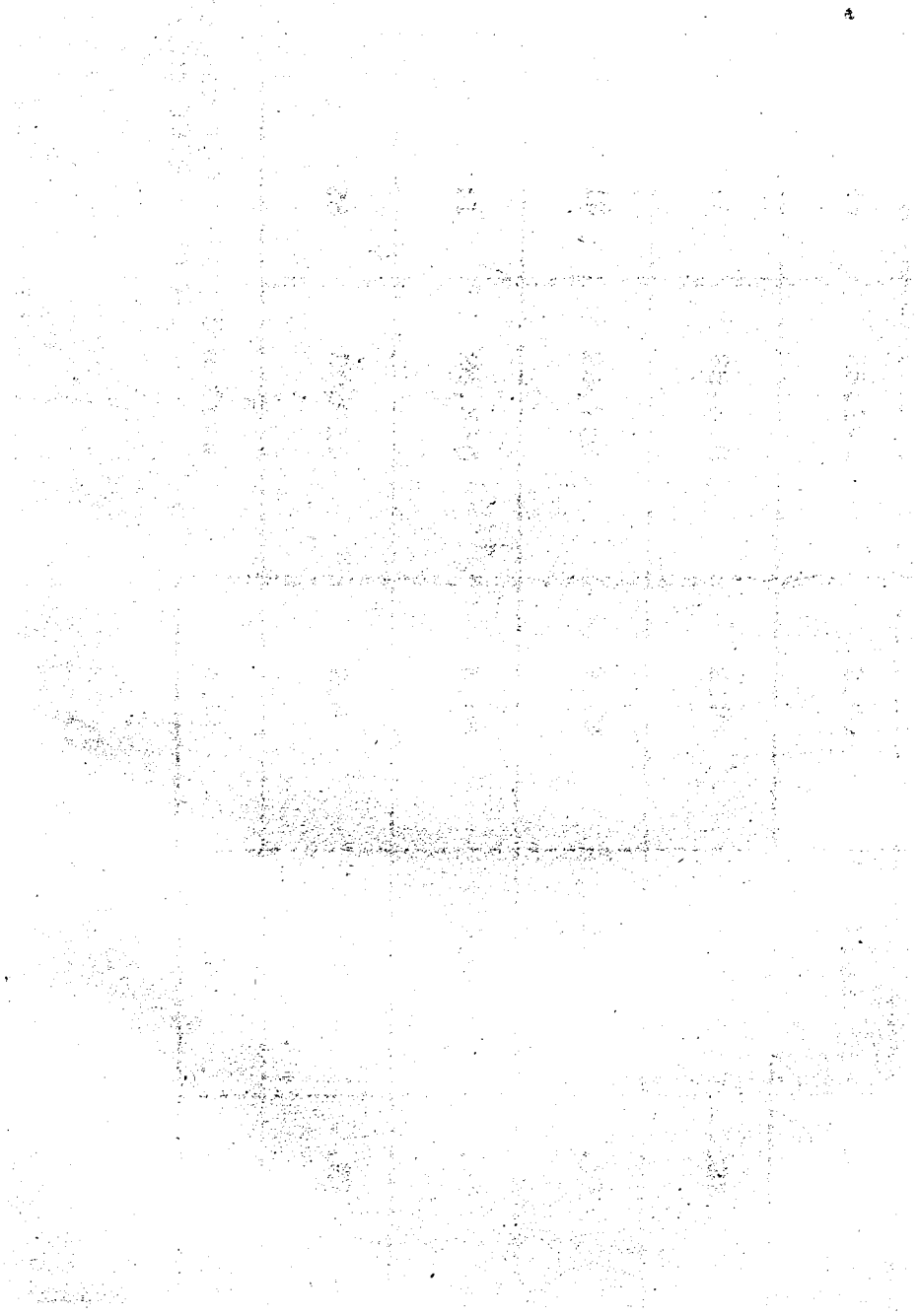

Table I. Shewing the numbers of Cases, Invalidings and Deaths, the number of days sickness and the Ratios for 1,000 men of Cases Invalidings and Deaths for Tuberculosis during the five years 1907 - 1911.

YEAR.	Cases.		Invalided.	Dead		Days Sickness	Ratio per 1,000 men bourne.		
	Total	Pulmonary Tuberculosis		Total	Pulmonary Tuberculosis		Cases.	Invalided	Dead.
1911	286	245	237	38	25	25,194	2.44	2.02	.32
1910	261	208	205	26	16	23,542	2.29	1.8	.22
1909	320	253	209	22	13	23,708	2.83	1.85	.19
1908	337	268	268	37	31	24,530	3.08	2.45	.33
1907	305	249	240	30	23	20,913	2.8	2.2	.27
Average Ratio per 1,000 for the five years 1902 - 1906.							3.66	2.59	.49

Table II The number of Cases of Tuberculosis and the Ratio per 1,000 in the different Ranks and Ratings for the three Years 1909, 1910, 1911.

YEAR		Commissioned & Subordinate Officers.	Warrant Officers.	Seamen.	Boys.	Engine Room Ratings.	Marines.	Officers' Stewards and Cooks.	Sick Berth Staff.	Ships Police.	Writers.	Ships Stewards Ratings.	Armourers and Blacksmiths.	Artisans.	Cooks.	Kroomen Seedies Lascars.	Miscellaneous.
1911	No. of Cases	10	9	101	6	89	27	6	8	3	3	2	5	3	9	-	5
	Ratio per 1000	1.44	4.53	2.4	.89	2.22	2.46	1.65	6.82	3.72	3.72	3.28	3.6	.85	5.52	-	-
1910	No. of Cases	9	5	91	7	72	33	11	2	3	3	-	1	3	3	-	9
	Ratio per 1000	1.35	2.65	2.15	1.15	1.87	3.06	2.08	1.75	3.84	3.84	-	.70	.86	2.06	-	-
1909	No. of Cases	13	3	105	13	88	31	9	10	2	2	8	2	5	11	2	10
	Ratio per 1000	11.96	1,68	2.46	2.59	2.45	2.85	2.52	8.84	2.54	2.54	12.9	1.3	1.42	8.61	4.70	-

Table III. Shewing the Ratio per 1,000 men of Cases Invalidings and Deaths in the different Fleets and Stations during the five years 1907 - 1911.

Year	Home Station			Home Fleet			Channel Fleet			Atlantic Fleet			Mediterranean Fleet			N. America & West Indies			China			East Indies			Australia			Cape of Good Hope			Irregular List		
	C.	I.	D	C.	I.	D	C.	I.	D	C.	I.	D	C.	I.	D	C.	I.	D	C.	I.	D	C.	I.	D	C.	I.	D	C.	I	D	C.	I.	D
1911	3·03	2·52	·4	2·01	1·67	·29				2·27	2·04	·22	2·86	2·76	–	2·47	2·02	·44	2·25	2·62	·56	3·47	3·47	·43	2·6	2·87	·28	2·77	1·85	·92	2·08	1·25	·41
1910	2·44	1·81	·48	2·14	1·69	·1				1·96	1·84	·11	2·63	2·03	·3	2·42	2·22	–	1·74	2·19	·36	3·5	3·	·5	2·69	1·79	·29	1·9	1·9	–	1·88	1·76	–
1909	2·93	1·94	·34	2·55	1·81	·15				2·43	2·1	·22	2·52	2·62	–	3·46	2·71	·24	2·63	2·49	·19	6·91	3·19	·53	3·85	1·78	–	3·54	2·65	–	2·8	2·24	–
1908	3·49	2·97	·34	3·17	2·46	·26	1·9	1·79	·16	2·72	2·25	·23	4·89	3·88	·57	1·91	1·27	·81	2·82	2·82	·85	3·48	2·9	·58	3·1	1·86	·93	2·63	·87	·87	4·3	4·3	·95
1907.	2·83	2·21	·35				2·56	2·03	·13	2·37	2·08	·09	3·22	2·94	·29	1·74	1·89	–	2·78	2·18	·39	2·68	2·68	–	2·77	1·54	·61	5·12	4·27	–	3·79	5·48	–

N.B. The Home Fleet was formed in 1908 and the Channel Fleet ceased to exist as such in 1909.

Table IV. Shewing the Ages of Officers and men finally invalided from the Royal Navy for Tuberculosis during the five years 1907 - 1911

Year	Under 20 years	Under 25 years	Under 35 years	Under 45 years	Over 45 years
1911	40	68	115	25	1
1910	24	72	96	25	1
1909	30	66	96	27	3
1908	32	112	119	18	2
1907	38	93	108	25	2

Table V. Shewing the length of Service of Officers and men invalided from the Royal Navy for Tuberculosis during the five years 1907 - 1911

Year	Under 1 year	Under 2 years	Under 3 years	Under 4 years	Under 5 years	5 to 10 years	10 to 15 years	15 to 20 years	20 years & upwards		
1911	18	24	13	14	15	60	66	34	5		
1910	13	11	11	14	14	79	40	23	13		
1909	16	11	17	9	11	74	50	18	16		
1908	16	18	18	22	22	111	47	16	14		
1907	13	25	16	25	10	97	47	24	9		

THE CAUSE OF PULMONARY TUBERCULOSIS.

Pulmonary tuberculosis is the result of the morbid changes produced in the lungs by the Bacillus Tuberculosis discovered by Koch in 1882. There are several varieties of the bacillus, the human, the bovine, and the avian types, and there is a form found in fish. Of these only the human and the bovine are of any great practical importance.

The Bacillus Tuberculosis is somewhat difficult of culture, being of a very slow growth, but its staining reactions are very characteristic. Being acid and alcohol fast it is easy to differentiate from other bacilli, and this fact more than compensates for its difficulty of culture.

It has great resisting powers and can live for months in dried sputum. When obtained from house dust it can be cultivated and will produce symptoms of tuberculosis when injected into susceptible animals. It also lives for weeks in decomposing tissues. It is quickly killed by direct sunlight and by such powerful disinfectants as carbolic (1-20), Mercuric chloride (1-1000), &c. Its great resisting powers and some phases of its cultural growth incline some authorities to regard it as a bacillary form of one of the Streptothrix group.

Tubercle bacilli reach the lung by two main routes, inhalation and ingestion, the human type being the type inhaled, and the bovine type mainly the type ingested. Koch in his London speech in 1901 laid down the fact that the principal source of infection was inhalation of the human bacilli derived from dried sputum.

Von Behring in 1903 went to the other extreme and stated that ingestion of tuberculous milk was the chief cause of infection in children and in adults. In the latter the infection was due to the waking up of bacilli ingested in childhood and lying dormant. Calmette and his school supported Von Behring, but went further and stated that in adults pulmonary tuberculosis was always due to the ingestion of Tubercle Bacilli, the bacilli reaching the lungs via the mesenteric glands, the broncho-tracheal glands, and the lymph channels and blood vessels.

Many experiments shewing how anthracosis of the lungs can be produced in animals by introducing Indian ink to their alimentary canals were produced as evidence of the ingestion theory, and opinion generally swung round to support Calmette's view. Now, however, men are returning to Koch's original view, namely, that inhalation of human bacilli from dried sputum is the chief cause of pulmonary tuberculosis in adults.

Sir John McFadyen reviews all the experimental evidence and comes to the following conclusions:

1. The inhalation of tubercle bacilli suspended in the atmosphere is a very certain method of infection in susceptible animals, even when small doses of bacilli are employed.

2. Experimental infection with tubercle bacilli by way of the alimentary canal is comparatively difficult to realise even in highly susceptible animals, and success is certain only when large doses of bacilli are administered.

3. With few exceptions, in animals experimentally infected with tuberculosis by way of the intestine the primary lesions are intra abdominal and the intra thoracic lesions when present are secondary.

4. Inhalation is probably the commonest natural method of infection in those species (man and cattle) in which the primary lesions of tuberculosis are usually intra thoracic.

5. Naturally contracted cases of tuberculosis in man and other mammals can be ascribed to infection by ingestion only when the lesions revealed at the post-mortem examination are confined to the abdomen, or when the existing abdominal lesions are recognisably older than those present elsewhere in the body.

Bullock also takes the same view, and gives the following arguments in favour of inhalation as the main cause of infection in pulmonary tuberculosis.

1. The great dissemination of tuberculous sputum by multitudes of consumptives.

2. The early anatomical lesions in the lungs.

3. That very minute doses induce tuberculosis when inhaled, the lung being apparently the most easily infected of all organs.

Kitasato also points out the fact that while pulmonary tuberculosis is as common in Japan as in any other country, cow's milk is drunk very sparingly, is almost never used for feeding infants, and that Japanese cattle are practically free from tuberculosis.

Further, in pulmonary tuberculosis the bacilli are almost invariably of the human type, as can be demonstrated by experiment in over 90% of the cases.

On the other hand, the Royal Commission on Tuberculosis in their Final Report stated that a considerable amount of human tuberculosis was caused by bacilli of the bovine type, and that tuberculosis may be communicated to man from infected milk and from tuberculous meat.

And the fact that the bacilli in pulmonary tuberculosis are generally of the human type does not entirely exclude the ingestion theory, for human bacilli may be ingested in food contaminated by consumptives, and also in considerable numbers by children crawling about floors and licking up infected dust. Bovine bacilli too may acquire the characteristics of the human type by long residence in the human body.

Hordr takes a middle course and states:

1. That there are two main routes of entry of the bacillus, ingestion through the alimentary tract and inhalation through the lungs.

2. That it is accepted by most authorities that the route by ingestion is commoner in children, and that by inhalation commoner in adults, this being proved by the fact that in children the bovine type of bacilli are commoner.

3. That tuberculous lesions developing later in life are more likely to be due to reinfection from without than to auto infection from a focus developed in childhood and lying dormant.

4. That other routes of infection are rare.

Summing up, we must conclude that while sources of infection may be found in food, principally in milk, and must be looked out for and guarded against, the chief source of infection in pulmonary tuberculosis lies in the inhalation of contaminated dust, and that the dust is contaminated by men who have an open tuberculous lesion.

Another factor which must not be lost sight of is the prevalence of old healed tubercular foci in many apparently healthy people. McNeil quotes the statistics of tuberculous lesions found at the autopsies of all children examined in four European Capitals as follows:-

Christiania.	Vienna.	Paris.	London.
42.5%	40%	38%	35%

He also did Von Pirquet's cutaneous reaction on 541 cases, 371 of whom were hospital cases ranging up to 12 years of age, and 170 of whom were boys from an industrial school ranging from 6 to 16 years of age. In the former 37.7% gave a positive reaction, and in the latter 59.4%, and among the boys there was practically no active tuberculosis.

So, many men in apparent perfect health may have in their lungs dormant tubercular foci. These foci may remain dormant all their lives, but there may come a time when, on account of exposure, overwork, worry or ill health, the bodily defences are weakened, and these dormant foci are kindled into active tubercular lesions. These cases then, and we must presume that there are a good proportion of them, if they are not actual tubercle carriers are at least potential sources of infection.

To quote Sir T. Clifford Allbutt, "In 1898 after I

had been working on tuberculosis at Leipsic with Birch-Hirschfield, I became much impressed with the probability that many persons pass through an attack of pulmonary tuberculosis without knowing it, whether by virtue of resistance or by mildness of invasion they suffer comparatively little and their peril is not recognised. They are 'off colour' for a while, or 'over-worked' or they have a troublesome 'catarrh' from which they recover. Since I brought this point of view before the profession, on opening the subject of phthisis at the Meeting of the British Medical Association in 1899, much additional evidence of its truth has accumulated. Some of these persons may be carriers, though in others the tubercle may remain long closed."

The two following cases would seem to bear this out. They are those of two marines who were nearly drowned owing to the swamping of a whaler while an armed party was being landed at Bundar Abbas to protect the British Consul there from attack by unfriendly Afghan tribes.

Briefly they are as follows:-

1. T. W. B., aet. 25, Private R.M.L.I., serving on board H.M.S. Perseus.

Placed on the sick list 17th May, 1912, having been nearly drowned by the swamping of the whaler on the previous day. He swallowed a large amount of water and severely strained himself in expelling it. During the night he had a dangerous haemoptysis. He subsequently developed cough and spit and signs of pulmonary tuberculosis. Tubercle bacilli were demonstrated in his sputum and he was invalided home. After a short stay in

the R. N. Hospital, Chatham, he was finally invalided out of the Service for pulmonary tuberculosis.

2. P. H. B., aet 24, Private R.M.L.I., serving on board H.M.S. Perseus.

He was nearly drowned in the same accident and was sent into hospital at Bundar Abbas unconscious. He recovered from the effects of submersion, but ten days later he developed a right-sided pleurisy. This cleared up but left him with a cough and expectoration, and signs of pulmonary tuberculosis developed. Tubercle bacilli were found in his sputum and he suffered the same fate as his companion.

Both men were apparently in good health when the accident happened, and it is quite conceivable that the shock, exposure and other effects of submersion may have weakened their resisting powers and caused dormant tubercular foci to kindle up into active tubercular lesions.

THE DIAGNOSIS OF PULMONARY TUBERCULOSIS.

The early diagnosis of pulmonary tuberculosis before tubercle bacilli have made their appearance in the sputum and while the physical signs are yet uncertain presents a difficult problem.

It is a difficult problem in the wards of a hospital where every opportunity for accurate observation of clinical signs and symptoms, and all means of laboratory and radiographic investigation are at hand; it is doubly difficult on board ship, where the noises incidental to ship life, the running of engines and the movements of the ship render accurate appreciation of early physical signs practically impossible, and where other methods of investigation, laboratory and radiographic, must of necessity be very limited.

Yet it is on board ship where space is limited and men live in constant close personal contact that it is of the greatest importance to recognise the cases at the earliest opportunity, in order that they may be removed to hospital before they spread infection broadcast.

When ships are within reach of the Naval Hospitals all suspicious cases can be sent in for full investigation, and Medical Officers now recognise the importance of early diagnosis and take advantage of this more and more, but it often happens when a ship is on isolated service that this is impossible. Then the onus of early diagnosis rests on the Medical Officer of the ship, who if he diagnoses or suspects pulmonary tuberculosis must make his own arrangements for the prevention of infection

and treatment of the conditions.

Recognising this, the Admiralty supply most large ships, all "parent" ships (ships in charge of small ship flotillas) and all ships on isolated service, e.g., gunboats on the Chinese Rivers, with an excellent microscope, having a 1/12 inch oil immersion objective, and a small but complete bacteriological chest.

In the early recognition of pulmonary tuberculosis every source of evidence must be carefully investigated. These sources are:

1. History.
2. Early symptoms.
3. Early signs.
4. Laboratory investigation,
   a. Examination of sputum for tubercle bacilli, the only positive evidence. Also examination of pleuritic fluid.
   b. Indirect evidence, as diagnostic tuberculin investigations, opsonic index, &c.
5. Radiography.

1. HISTORY.

Pulmonary tuberculosis is not now regarded as a hereditary disease, for it is impossible to conceive of the bacilli being passed from parent to offspring in the sperm or ovum, though it may be acquired during intra uterine life through the placental circulation. But a history of tuberculosis in the family generally means a transmission of diminished resistive powers, and it may mean a history of exposure to infection, and that at an early age and over a considerable period of time.

Exposure to infection also occurs where an undoubted case of pulmonary tuberculosis is discovered on board ship, and special attention should be given to all pulmonary symptoms developing in his messmates.

Certain diseases also either predispose to or are early manifestations of tuberculosis. These are

1. Pleurisy.
2. Bronchitis and Broncho-pneumonia.
3. Lobar pneumonia.
4. Laryngitis.
5. Cervical lymphadenitis.
6. Indefinite febrile attacks.
7. Dyspepsia with anaemia.

Pulmonary symptoms following a history of any of these should be carefully investigated and watched. Haemoptysis when it is ascertained that the blood comes from the lungs and not from the mouth, nose, throat or stomach, and when haemoptysis due to cardiac disease or cirrhotic disease of the liver is excluded, is very strong, practically diagnostic evidence of pulmonary tuberculosis.

2. EARLY SYMPTOMS.

1. Pyrexia, especially a swinging temperature rising in the evening and falling in the morning, though the temperature may be inverted.
2. Increase in the pulse rate.
3. Loss of weight.
4. Anorexia and dyspepsia without apparent cause.
5. Night sweats.
6. Cough and expectoration.
7. *Pain in the chest.*

3. EARLY PHYSICAL SIGNS.

The sites of election in looking for early signs are:-

1. Just below the middle third of the clavicle.
2. Below the outer third of the Clavicle. Frequently signs are made out better behind in the supraspinous fossa.
3. Beside the fifth dorsal vertebra (The apex of the lower lobe).
4. More rarely at the bases.

Early signs are:

Inspection.

1. Suggestive malformation of the chest.
2. Flattening in any of the above situations.
3. Diminution of movement.

Palpation.

Confirms the above.

Percussion.

Slight relative impairement of note on the affected side, or the note may be of a higher pitch than on the sound side. There may be slight tenderness on percussion.

Auscultation.

The breath sounds may be feeble. Expiration may be slightly prolonged. The breath sounds may be jerky or even cogged-wheel in character. Fine râles may be heard, which are brought out on making the patient cough.

In the further stages, where consolidation or cavity formation have taken place, the physical signs become more definite and diagnosis becomes easier.

LABORATORY DIAGNOSIS.

The finding of tubercle bacilli persistently or in numbers in the sputum is proof positive of pulmonary tuberculosis and in suspected cases the sputum, if any, should be examined at frequent intervals till the bacilli are found.

Every effort should be made to obtain sputum, and it may be necessary to check the habit of swallowing it, a habit which may be a pure bad habit per se, or may be resorted to when the man wishes to avoid detection. In such cases it may be necessary to examine the faeces. The first sputum coughed up in the morning is the most lightly to contain bacilli, and it should be examined by the Ziehl-Neilsen method frequently, half an hour at least being spent looking over each slide.

If the results are negative, the sputum should be shaken up with ten times its bulk of carbolic acid 5% and films made from the deposit after settling, and stained

by the Ziehl-Neilsen method.

Failing this, one of the digestion methods should be tried. Of these the antiformin method is probably the best. One method of employing this is as follows:- Shake up the total sputum for 24 hours with antiformin (15% solutions of bleaching power and caustic soda, equal parts) and allow to remain for four or five hours (it may be incubated at 37°C.). Centrifugalise, wash the deposit with saline, again centrifugalise, make slides of the deposit and stain. The antiformin disintegrates the albuminous matter and the bacilli are concentrated in the deposit. The antiformin method should also be used when dealing with faeces.

Other methods, Much's, Hermann's, &c., are of less value.

Inoculation of susceptible animals with sputum from suspected cases can be employed only where a vivisection licence is held (Haslar and Greenwich are the only two in the Royal Navy).

INDIRECT METHODS.

Tuberculin tests. These depend on the principle that once the body is infected with tuberculosis it becomes supersensitive to the toxins of the bacilli when these are introduced into it.

1. Koch's test. Koch's old tuberculin is introduced subcutaneously:

.001 cc)
.005 cc) doses at two-day intervals if no
.01 cc) reaction.

If after any dose the temperature rises .5°F., repeat

that dose. A rise in temperature of 1°F. may be taken as a positive reaction. For weakly people an initial dose of .0001 cc may be given.

Reactions are general, local and focal.

General. Rise of temperature.
Increase of pulse rate.
Headache, malaise, &c.
Abdominal and joint pains.

Local. Pain, swelling, redness, &c., at the site of injection.

Focal. Increase of physical signs, cough expectoration, pain in the chest, &c., or tubercle bacilli may appear in the sputum.

2. Von Pirquet's Cutaneous Reaction.

Rubbing in of solution of tuberculin into scarified skin.
Use several strengths and a control.
A positive reaction obtains when there are papules and erythema.

3. Calmette's reaction.

Introduction of 1% solution of tuberculin into the conjunctival sac.
Congestion and exudate are taken as a positive reaction.

4. Moro's Reaction.

Rubbing in an ointment of equal parts tuberculin and lanolin into the unbroken skin.
Positive reaction as in Von Pirquet's method.

Horder sums up the tuberculin methods as follows:- "Of the tuberculin tests there is little doubt that the subcutaneous is the least equivocal in its results. Its great disadvantage is that it cannot be undertaken in febrile cases. It is more likely than the others to demonstrate an active focus as against a quiescent or arrested one."

That is the fault of all the methods, viz., that they give a positive reaction in cases who have had a tuberculous lesion even though they are now apparently cured.

Dr. G. B. Dixon writes: "A positive Von Pirquet, Calmette or Moro alone can never justify us in making a definite diagnosis of pulmonary tuberculosis nor can the occurrence of a 'local' or 'general' reaction after the subcutaneous test, but the presence of a 'focal' reaction is evidence upon which the most exacting observer is justified in making a diagnosis of pulmonary tuberculosis."

Other tests are

The compliment fixation test as in the Wassermann test for syphilis. This is open to the same objection as the tuberculin tests, that it does not distinguish an active from a quiescent lesion.

The Opsonic Index. An abnormally high or an abnormally low opsonic index, i.e., below .8 or above 1.2, or an index that varies as the result of rest, exercise, &c., is supposed to be diagnostic of tuberculosis, but it requires a skilled observer, and one who is in almost daily practice.

Lastly, cytological evidence in cases of pleurisy may help to distinguish a tuberculous case from a pyogenic one, as in the exudate from the former the cells are mainly lymphocytes, in the latter polymorphonuclears, equal numbers signify a mixed infection.

RADIOGRAPHY.

Screen. A difference of illumination of the two lungs, less mobility of the diaphragm on one side, is significant of pulmonary tuberculosis. Holst says that just before coughing the apices brighten and approximate to the middle line. Absence of this sign is very suggestive.

Negative: Shadows or mottling usually near the apices or along the bronchi suggest tubercular foci, but other conditions, atheroma, bronchiolyths, &c., give similar shadows, and often interpretation is difficult.

For the radiographic diagnosis of pulmonary tuberculosis an experienced and highly trained observer is necessary.

The Naval Surgeon may be unable at sea to avail himself of such means of diagnosis as radiography, and the more elaborate laboratory methods of investigation, but careful clinical observation repeated at intervals upon his patient and under different circumstances (at rest, after light work, and after hard work) aided by such methods of seeking for the tubercle bacillus as the Ziehl Nielsen method and the antiformin method, will almost invariably ensure a correct diagnosis.

PROPHYLAXIS OF PULMONARY TUBERCULOSIS IN THE ROYAL NAVY.

Before considering the special measures taken to prevent the spread of pulmonary tuberculosis, a few notes on the general hygiene of the Royal Navy may be useful.

It must be remembered that ships are primarily fighting machines, and many considerations must be subjected to those of armaments, offensive and defensive.

Accommodation: This on fighting ships is very limited, owing to the relatively large crew and the space taken by armaments and magazines, engines, boiler rooms, and coal bunkers, speed and range of action being very important. The cubic space in Super-Dreadnoughts works out at about 80 cubic feet per man, which compares very unfavourably with the 1,000 cubic feet required by the Board of Trade in a workhouse. At present, however, it is the best available, and may be increased in the future as labour-saving appliances, internal combustion engines, &c., may reduce the number of men necessary very considerably.

Ventilation: This is one of the most important and at the same time one of the most difficult subjects in naval hygiene.

The chief difficulties are:

1. The small amount of cubic space per man.
2. The impervious nature of the material used in ship construction.
3. The division of the ship into watertight compartments which have no intercommunication.
4. The fact that much of the accommodation lies behind armour which would be weakened if pierced by apertures, and also that much of the space is below the water line.

Also we might add the traditional dislike of fresh air by the average sailor.

In the older type of ship ventilation was almost entirely natural. The air was renewed by gaseous interchange through ports, scuttles, hatches and skylights. Spaces below the water line were ventilated by cowls which could be trimmed to or from the wind, and made to act both as supplies and exhausts. The only compartments supplied by fans were the engine and boiler rooms, much air being necessary in the former to keep the engines as cool as possible, and in the latter for the combustion in the furnaces. The more efficient ventilation in these compartments explains why pulmonary tuberculosis is less common in stokers and engine room ratings than in seamen. There are still many ships of this type in commission, and in small ships natural ventilation is the only kind practicable.

Natural ventilation is defective because of its uncertainty. Bad weather may cause the shutting of all inlets and outlets, and in sleeping compartments the men nearest the scuttles almost invariably close them. Cowls are useless when the ship is stationary and there is no wind. They are also undesirable as they increase the size of the ship as a target.

In modern large ships ventilation is almost entirely artificial, and is only supplemented by natural ventilation in compartments which are above the water line and not behind armour.

Air is impelled by fans through ventilating trunks

which have louvred openings into the various compartments. The division of the ship into watertight compartments necessitates a decentralised system. The fresh air is drawn through "mushroom tops" situated on the upper and flying decks, having a mechanical arrangement which allows air to enter but prevents water. The air passes over hot pipes and so is warmed, but can be directed into the trunks by a by-pass unheated. The results of this method are very good, considering the smallness of the cubic space per man.

Surgeon Edgar, R.N., and Assistant Constructor Bentley, R.C.N.C., conducted some experiments in the Bellerophon, an improved Dreadnought, which gave the following results.

Two typical compartments, the Petty Officers Mess, and the Stokers' Mess Deck, were taken, and the times 10 a.m. and 3.30 a.m., when the atmosphere of these was best and worst, were chosen.

	Time.	CO_2 per 1,000.	General Impression.
Petty Officers Mess	10 a.m.	0.51	Fairly good.
	3.30 a.m.	1.2	Close.
Stokers' Mess Deck	10 a.m.	.75	Close
	3.30 a.m.	1.1	Very close.

This gives a very fair result, though the CO_2 readings are higher than those allowed for well ventilated rooms in most books on the subject.

Leonard Hill, however, has proved that the discomforts and dangers of badly ventilated compartments are not due to the increase of CO_2, the diminution of oxygen or even to poisonous emanations in the breath, but to

increased heat and increased humidity, hot damp air not only relaxing the nasal and buccal mucous membranes, and thus rendering them more vulnerable, but being most favourable to the life and activity of most pathogenic bacteria. CO_2 up to 4% in the atmosphere only causes deeper breathing and the amount in the lungs remains unaltered when it is increased up to 6%; and the amount of oxygen in a badly ventilated room rarely is less than that of some health resorts at an altitude of 10,000 ft.

He concludes from this that an atmosphere which can be kept cool and dry is generally all right and this can be accomplished, failing other methods, by keeping the existing atmosphere moving.

The advantages of artificial ventilation are, therefore, a constant supply of fresh air; or if the inlets have to be closed down on account of heavy weather or large-gun practice, the existing atmosphere can be kept circulating and the temperature and relative humidity to a certain extent kept down.

Suggested improvements in ventilation would be

1. More cubic space per man.
2. Separate ventilating and heating systems.
3. a Better disposition of the inlets in compartments.
4. A combined supply and exhaust system.
5. A method of preventing objectors to fresh air tampering with or closing the inlets.

At present a Commission on Ventilation in the Royal Navy is sitting. Their recommendations have not been published yet, but when they are, good results may be looked for.

Summing up, ventilation on board ship, though it still has its faults, is certainly much better now than

formerly, and the decrease in pulmonary tuberculosis in late years is no doubt largely due to this improvement.

HEATING AND LIGHTING. Heating in modern ships in the men's quarters is accomplished by passing the air supplied by the ventilating system over hot pipes.

Opinion now is that air so treated loses a certain vitalising principle, and I think more satisfactory results would be obtained were separate systems introduced, the heating being effected by radiators.

Lighting. In modern ships, as armour increases, so artificial light replaces natural. Electric light is almost invariably used, and is of excellent quality and quantity, but the unavoidable absence of sunlight, which has so great a lethal effect on the tubercle bacillus, is to be deplored.

Still, on the principle of bringing Mahomed to the Mountain, bedding, &c., can and ought to be brought up on deck and exposed to fresh air and direct sunlight as much as possible.

FOOD. Two factors have in recent years simplified the food problem in the Navy. The first is steam propulsion rendering the time between ports very much shorter; the second is the introduction of facilities for cold storage. Most modern ships can now carry a fortnight to three weeks' supply of fresh provisions. This change from the days of salt junk and weevily biscuit must be reflected in the general health of the sailor. The diet now on board ship is good, varied and well cooked, and ample time is allowed not only for

eating but also for the short period of relaxation afterwards that so aids digestion and assimilation.

Fresh meat and vegetables are obtained from the Government Victualling Yards or from private contractors; they can also be purchased locally where it is impossible to get them by the former means. Fresh food is inspected by the Paymaster when it comes on board, and if he has any doubts as to its purity he calls in the Medical Officer of the ship to see it. The decision of the latter is final. Paymasters receive a special course in food inspection, and it is part of the courses for Medical Officers at Haslar and Greenwich. All fresh milk received on board must be boiled or pasteurised, and the result verified by means of the Ortol Test.

Modern large ships have bakeries and excellent bread is made on board. In small ships it is got by contract. Biscuits when used are now supplied in air-tight tins.

Officers provide their own cooks. Those for the men come from the Government Cookery School at Portsmouth. Cooks and Bakers must undergo a special medical examination.

Each man is allowed a certain ration and in addition gets fourpence a day for the purchase of additional articles of diet from the ship's canteen. The latter is in the hands of private contractors, subject to Admiralty supervision.

The Naval ration is as follows:-

	Biscuit or bread	1½ lb.
	Jam	2 oz.
	Rum	⅙ pint.
	Coffee	½ oz.
Daily	Preserved meat	4 oz.
	Sugar	3 oz.
	Soluble Chocolate	¾ oz.
	Condensed milk	2¾ oz.
	Tea	⅜ oz.
Every 4 Days	Salt	1 Oz.
	Mustard	½ oz.
Weekly	Pepper	¼ oz.
	Vinegar	¼ pint.
Daily when procurable	Fresh meat	¾ lb.
	Vegetables	1 lb.

The ship's company is divided into messes, the rations are drawn in bulk for each Mess, which decides how they shall be cooked, stew, roast, &c.

This ration equals

Proteid	117 grammes	or 479.43 calories.
Carbohydrates	535.2 "	2194.32 "
Fats	22.18 "	206.27 "

which with the additional articles purchased, usually of high calorific value, jam, cheese, &c., gives a total well over 3,100 calories, the amount recommended for men doing moderate muscular work.

Meal times are:

5 a.m. to 5.30 a.m.	Cocoa.
8 a.m. to 8.45 a.m.	Breakfast.
12 noon to 1.15 p.m.	Dinner.
4.15 p.m. to 4.45 p.m.	Tea .
7.30 p.m. to 8 p.m.	Supper.

Total 3 hours 30 minutes.

CLOTHING. Sailors are well and warmly clad; service flannel which is much worn, being of particularly good quality. The sailor's uniform is too well-known to be

described here. It is hygienic and comfortable.

REST AND RELAXATION. The ship's Company have seven hours sleep nightly, 10 p.m. to 5.a.m., and provided a man's conduct is good he is very well off in the way of leave.

EXERCISE. Since the abolition of masts and yards it has become increasingly more difficult to provide sufficient exercise to keep the sailor fit. A system of Swedish Gymnastics was introduced some years ago, which is now giving admirable results. The system aims not at developing large muscles and encouraging fancy tricks on apparatus, but at the quickness and co-ordination of all muscles in the body. The exercises are carefully graduated, the hardest being in the middle of each "table," so that the heart and respirations gradually quieten down. On board a quarter of an hour is done daily on the upper deck by all hands, the training being optional in the case of Petty Officers, and men over 35 years of age.

PERSONAL HABITS AND CLEANLINESS. In the way of personal habits and cleanliness the sailor compares well with any other class of man. Drink beyond the daily tot of grog cannot be procured on board, and if he has outbursts ashore they are only periodic and less likely to do harm than continual soaking. Sobriety in the Royal Navy is increasing each year.

Spitting has tended to disappear concurrently with chewing, which is now in the Navy a thing of the past.

WATER SUPPLY. Fresh water is obtained by distilling; the distilled water being aerated to take away the mawkish taste. At times it is got ashore from guaranteed supplies. Where the supply is uncertain, i.e., at a Foreign port, samples are tested by the Medical Officer, and though a chemically pure water may not be bacteriologically pure water, it is the best that can be done on board ship.

DRAINAGE AND DISPOSAL OF REFUSE. With an abundant supply of sea water at hand, efficient means of pumping, and the finest refuse destructor in the world all round the ship, drainage and disposal of refuse presents no difficulty and is thoroughly efficient.

Ashore the sailor lives in barracks which are up-to-date and hygienic; otherwise his life, food, &c., are as on board ship.

To conclude, the Naval man nowadays is well housed, well fed, well exercised, and well looked after, and his life, food and surroundings compare most favourably with those of similar classes ashore.

The special measures taken in the Royal Navy to prevent the spread of pulmonary tuberculosis are run on the following lines:

1. The early removal of foci of infection, in the shape of tubercular men with "open" lesions.
2. The education of men in health principles, the dangers of disease, and the modes of infection.
3. Improvement of the general hygiene of the men and of the Navy generally.
4. Careful examination of recruits.

1. All cases of pulmonary tuberculosis, where tubercle bacilli have been demonstrated, are invalided out of the service, both officers and men.

Early diagnosis has already been discussed, and mention has been made of the excellent microscopes supplied to ships. All methods of diagnosis are available at the Home Hospitals where cases are sent for confirmation before being finally invalided.

2. Medical Officers of ships are now required to give quarterly to the whole ship's company, taken in divisions, a series of health lectures, each series to consist of four lectures on the following subjects:

1. General Hygiene and Health Principles.
2. Tuberculous Disease and its Prevention.
3. Venereal Diseases.
4. Alcohol and its Abuses.

That these lectures do a lot of good there is no doubt. Most men take a great deal of interest in them, as evidenced by the intelligent questions often asked at the end of a lecture.

3. Recently a Commission has been enquiring into the subject of pulmonary tuberculosis in the Royal Navy. Their recommendations were embodied in a Circular Letter (No. 14), dated 20th May, 1912, as follows:-

"My Lords Commissioners of the Admiralty having had under consideration the steps which should be taken for the prevention and early detection of cases of tuberculosis in H. M. Navy, have decided that the following measures are to be brought into operation without delay.

2. Constant medical observation is to be made of

men with a history of haemoptysis, bronchitis, pleurisy, or who appear to be in a low state of health, and of those who are found to be losing weight. Men who suffer from colds and coughs should be encouraged to seek for advice. When medical examination of the Ship's Company takes place special attention should be paid to possible cases of pulmonary tuberculosis.

3. The weight of all officers and men under the age of 36 is to be taken once every quarter and recorded in a book kept for the purpose. This duty is to be carried out by Physical Training Instructors and the record is to be communicated to the Medical Officer.

4. In order to diminish dust the decks are to be damped with a disinfectant before sweeping up, but any great dampness between decks is to be avoided. Every endeavour should be made to prevent spitting on the deck, and this point should be emphasised in health lectures.

5. Blankets and deck cloths are to be sterilised from time to time, as necessary, by ships carrying disinfectors.

6. All fresh milk is to be pasteurised, or boiled, before issue, and the result verified by the Ortol test."

These was supplemented by Order 810 in the Admiralty Weekly Orders as follows:-

"1. So far as possible the chests of all men are to be thoroughly examined before draft. This applies specially to small drafts and drafts for Foreign Service. In other cases time may not result of a complete examination.

2. The Medical Officer for Physical Training when

borne is to record on the Medical History Sheets the state of the chests of all men passing Physical Training.

3. As soon as a ship commissions very special attention is to be given by the Medical Officer in Charge to see that Par. 2 of circular letter 14 is carried out.

4. A thorough examination of all the men's chests is to be made as soon as possible, beginning with men on the sick and excused list, and anyone attending the Sick Bay for examination, e.g., any men in small drafts leaving or joining the ship who have not been examined lately.

5. The result of every examination is to be entered on a man's Medical History Sheet, and in an alphabetical book to be kept in each ship for information on board. This will prevent repeated unnecessary examinations.

6. On a ship paying off, notes of those men who have been under observation are to be sent to the Medical Officer in charge of the depôt, who will send like notes to ships on commissioning.

7. The examining of chests by Medical Officers should coincide so far as practicable with the recording of weights by Physical Training Officers (par. 3, Circular letter 14)."

A further measure which should be emphasised is the disinfection that should be employed when a case of tuberculosis has been discovered. All men whose hammocks have been slung within a certain radius of the man should have them disinfected, and a modified scheme of disin-

fection should be laid down, as in the case of one of the infectious fevers. Large ships now carry efficient disinfectors of the Washington Lyons type, and the problem does not present much difficulty.

With regard to par. 4 of the Circular Letter, reference may be made here to a lecture delivered by Fleet Surgeon Gaskell, R.N., to the United Services Medical Society. He pointed out that though the cleanliness of a man of war was proverbial, yet hygienically it was not perfect. This he ascribed to

1. Overcrowding.
2. Defective methods of removal of dirt.
3. Dust-traps, as corners in angle-irons, &c., cork painting, indifferently laid corticene on decks, or corticene worn and cracked, allowing filth to accumulate underneath, fancy woodwork placed round masts, &c., &c.

The remedies he advocated were:

1. Rounded corners and smooth surfaces in living quarters.
2 Vacuum cleaning.
3. Washing canvas deck cloths and covers for tables.
4. Enamelled iron tables, &c., on the mess decks.

THE TREATMENT OF PULMONARY TUBERCULOSIS IN THE NAVY.

When a man is discovered to have pulmonary tuberculosis on board ship he is sent to one of the Naval Hospitals at the earliest opportunity. Till that can be done treatment on board must be largely dictated by circumstances. If the weather permits the best plan is is to screen off part of the upper deck for him, as then he has the benefit of open air treatment, and the risk of infecting others is reduced to a minimum. If that is impossible in the case of heavy weather, &c., the best means available must be adopted. He may be kept in the Sick Bay, in one of the casemates, or a portion of the mess deck may be screened off for him. Precautions against infection, destruction of sputum, and sterilisation of utensils, &c., used by him are of the utmost importance. The remedial agencies used will depend on the individual practice of various Medical Officers. Cases taking passage on H. M. ships from Foreign to Home Hospitals are also treated on these lines.

In the Naval Hospitals treatment of pulmonary tuberculosis is carried out on moderate lines, and extremes like overfeeding are avoided. Cures cannot be effected, as cases are only kept for three months at the longest, but it is endeavoured in that time to get the man as physically fit as possible before his discharge. The Following is the general plan of treatment adopted at the R. N. Hospital, Chatham.

A man sent in for observation for pulmonary tuberculosis is placed in a general ward where he is physically examined and his sputum frequently examined for tubercle bacilli.

When tubercle bacilli are found he is transferred to the tuberculosis ward, and is given the choice of being brought forward for survey and invalided at the earliest opportunity, or of receiving the benefit of three months' treatment.

A special ward is kept for these cases. It is well ventilated by the usual means of ventilation, and the windows are kept wide open day and night, save only in gales of wind, when they are shut on the windward side. It is heated by radiators and stoves, and the temperature is kept as near 65°F. as possible.

The patients get a generous diet. They get the full diet of the hospital as follows:-

Bread	1 lb.	Oatmeal	1 oz.
Beef, Mutton, &c.	10 oz.	Soluble Chocolate	½ oz.
Potatoes	8 oz.	Cheese	1 oz.
Other vegetables	6 oz.	Mustard, salt, vinegar and pepper as requisite.	
Tea	4 drams.	One rice or custard pudding 1 oz	
Sugar (moist)	3 oz.	of rice or one egg, ½ oz.	
Milk	¾ pint.	sugar, and ½ pint milk.	
Butter	1½ oz.		

In addition they get the following extras:

Bacon	3 oz.
Milk	1 pint.
Eggs	2
Calves foot jelly,	¼ bottle.
Apples	2, or the equivalent in various fruits as they are in season.

They may choose beef, mutton, pork, fowl, rabbit, or fish for dinner, due regard being paid to the general routine of the hospital.

The usual remedial treatment is adopted, and they

are allowed treatment by tuberculin if they wish it.

They are encouraged to be in the open air as much as possible, those who are unable to walk are wheeled out in chairs, and those confined to bed have their beds carried out in fine weather, a special part of the grounds being used for the purpose.

Tuberculous cases are not entirely segregated from the others, but they are not allowed to go to church, nor to attend concerts or other entertainments.

In the grounds they must carry spitting bottles. Spitting bottles and other articles used by them are disinfected every morning, and all refuse and unused food from the ward is destroyed by burning.

Treatment on these lines is carried out at the other Naval Hospitals. At Haslar, however, special wards have been built on sanatorium lines, and tuberculous patients are more completely separated from others.

TUBERCULIN TREATMENT.

The object of tuberculin treatment is to establish in the patient immunity to the tubercle bacillus and its toxins. This is accomplished by the formation of antibodies and their introduction to the seat of disease.

Two conditions are necessary.

1. Stimuli to produce the antibodies.
2. Power of response to these stimuli in the tissues.

When those two conditions occur naturally, spontaneous cure of the lesion takes place, and to have perfect results these two conditions must be at an optimum. Stimuli must not be overproduced nor underproduced, and the power of response must be of a high order.

Over-production of stimuli results in the disease assuming an acute form, giving rise to pyrexia and other distressing symptoms. Under-production results in the disease becoming chronic.

With this knowledge, treatment of the disease can be proceeded with on very sound and rational lines.

If there is an overproduction of stimuli it means that toxins are being liberated into the general circulation at too rapid a rate for the tissues to deal with them; in fact, that the patient is giving himself a series of auto-inoculations. The treatment for this condition is rest, absolute rest, what is often termed "typhoid rest."

Inadequate powers of response must be treated by improving the general condition of the patient by diet,

fresh air, tonics, allaying distressing symptoms such as cough and haemoptysis, and treating sleeplessness.

Under production of stimuli must be treated by trying to produce them, and this can be done in two ways.

1. By inducing auto-inoculations.
2. By administering tuberculin.

1. Auto-inoculation is practised at Frimley by Marcus Paterson's Method with excellent results. The inoculations are induced by graduated labour and are controlled by rest. This form of treatment, however, is not practicable in Naval Hospitals, because of the shortness of the time available, and the lack of means of giving graduated work.

2. A small dose of tuberculin when given to a tuberculous case acts as a stimulus to produce antibodies, thus producing a degree of immunity which lasts a certain time. By giving further doses increasing in amount before the immunity of the last dose has passed off, it is possible to establish a continuous and an increasing immunity. This form of dosage is termed the "intensive method" of administering tuberculin.

Inman classes cases of tuberculosis as follows:-

1. Resting febrile, i.e., cases which have fever while at rest.
2. Ambulant febrile, resting afebrile, i.e., cases which have no fever while at rest, but have fever if they walk about.
3. Ambulant afebrile, i.e., cases which have no fever while getting about.
4. Working afebrile; really a part of class 3.

To cure or improve the first class rest must be the means adopted.

The second class tend to cure themselves, but

unfortunately they tend to slip into the first or third classes.

The third class when left alone become chronic; there is an under production of stimuli. This class gives the cases suitable for tuberculin treatment, and by far the bulk of cases of pulmonary tuberculosis in the Navy belong to this class.

Tuberculin is non toxic to a non-tuberculous person even in fairly large doses, but is very toxic to persons having tuberculous disease. The tissues of the latter are sensitive to tuberculin. This sensitiveness is said to be due to a lysin which breaks down the tuberculin and forms a toxin. These toxins acting on the tissues give the "reaction."

Three forms of reaction are recognised:

1 Local; Hyperaemia, &c., at the side of injection.
2. General; Fever and general symptoms.
3. Focal; Hyperaemia at the focus of disease.

It is this focal hyperaemia which effects the cure by bringing the antibodies in the blood to the site of the lesion.

Therefore in giving tuberculin we aim at getting a focal reaction without getting either a general or a local one, and fortunately the focal reaction is found to be the most sensitive of the three.

In administering tuberculin by the intensive method there are three main schools.

1. Those who begin by fairly large doses, increase rapidly, and at short intervals. They get general reactions, often, and sometimes fairly severe. Camac

Wilkinson is the great advocate of this school.

Immunity is established more rapidly, but the patient suffers much discomfort and there is some danger.

2. Sahli's school begin with small doses, increase slowly, give longer intervals, and try never to have any general reaction. The argument against this school is that they waste unnecessary time in establishing immunity.

3. The Moderate School who steer a middle course between the other two. They are moderate in their doses, increases, and intervals, and aim at slight general reactions as indicated by a rise in temperature of about 1° F. This is the plan adopted at the R. N. Hospital, Chatham.

Of tuberculins there are many, both human and bovine. The commonest are

Exotoxic Tuberculins.

1. Bouillon Filtrates.
   Tuberculinum Originale Alt — T.O.A. — human.
   Perlsucht Tuberculinum Originale — P.T.O. — bovine.

2. Old Tuberculins (Concentrated bouillon filtrates)
   Kochs Old Tuberculin — K.O.T. — human.
   Perlsucht Tuberculinum — P.T. — bovine.

Endotoxic Tuberculins.

3. New Tuberculins.
   Tuberculinum Ruchstand — T.R. and P.T.R.
   A suspension of finely ground bacilli.
   Bacillary Emulsion — B.E. and P.B.E.
   An emulsion of dried and powdered bacilli.

4. Special Tuberculins such as Denys' and Beraneck's.

These tuberculins vary in strength, the strongest is K.O.T. and the weakest T.O.A. and P.T.O. Advantage of this is taken by giving tuberculins in certain

sequences, beginning with one of the weaker ones, and going on with a stronger one as immunity becomes established.

Tuberculin may be given by the mouth or by inunction, but it is almost invariably given hypodermically.

Bovine tuberculins are said to be more effective when the lesion is produced by the human type of bacillus, and vice versa, and as in pulmonary tuberculosis bacilli of the human type are almost invariably met with, bovine tuberculins are particularly useful.

The sequence generally used at Chatham is the P.T.O., P.T., K.O.T. sequence.

As regards the selection of cases for tuberculin, I have already indicated the most suitable ones. Fever and rapid pulse must be reduced by rest before commencing treatment. With an evening temperature of 100°F. or under, and no great daily swing, a cautious beginning may be made. Haemoptysis is not a contra-indication, provided severe reactions are avoided. The chief contra-indication is absence of response to the stimuli. In cases of mixed infection, or where there are great numbers of organisms other than tubercle bacilli in the sputum, an autogenous vaccine given first will often do much good, and pave the way for tuberculin. When giving tuberculin a complete temperature chart must be kept and the temperature taken at least thrice daily, otherwise reactions may be missed. One reading ought to be taken about 5 p.m., as the temperature in most cases of pulmonary tuberculosis is highest about that time. The urine and sputum should be examined frequently, and all signs and

symptoms watched and noted.

DOSAGE. A patient with normal temperature and in fairly good health is started with .002 cc. P.T.O. He is kept in bed on the day of injection and the temperature, &c., noted as above. If there is no great reaction he is given a larger dose in three days' time, and the dose is gradually increased.

The general scheme of dosage is as follows:-

P.T.O.	P.T.	K.O.T.
.002	.01	.01
.004	.02	.02
.006	.03	.03
.01	.05	.05
.016	.07	.07
.02	.1	.1
.03	.16	.2
.05	.2	.3
.07	.3	.5
.1		.7
.16		1.
.2		2.
.3		3.

Three day intervals are usually allowed, but these depend on the response of the patient to the tuberculin, as does also the increase of the dosage.

Owing to the shortness of the men's stay in hospital, a full course can never be given, in fact the cases never go much further than .05 P.T.

The indications that tuberculin is benefiting the patient are:-

1. Improvement in his general health.
2 Feeling of fitness and improved appetite.
3. Increase of weight.
4. Reduction of temperature and a lessened daily swing.
5. Diminution or disappearance of tubercle bacilli in the sputum.
6. Disappearance of cough and sputum.
7. Improvement in the physical signs.

Tuberculin treatment should be carried on coincidently with other remedial agencies, open air, feeding, &c., to get the best results. The tuberculin then supplies the necessary stimuli and the other treatment improves the powers of response.

Tuberculin treatment on these lines is offered to all suitable cases, but is in no way forced upon them; and it is, I think, an indication that the treatment is beneficial that nearly all men are anxious to have it. Men coming in at first sometimes fight shy of it, but they talk it over with the other men in the ward, and generally ask for it in the course of a few days. When we started it first, and in our inexperience had a few severe reactions, even that did not deter men from going on with the treatment, or others from volunteering for it.

THE DISPOSAL OF TUBERCULOUS CASES.

As has already been stated every case of pulmonary tuberculosis is invalided out of the service either at the first survey after his admission or after three months' treatment.

He is brought forward for survey by the Senior Medical Officer of the section, with the approval of the Principal Medical Officer of the Hospital. The Survey Board consists of a Post Captain, two Senior Medical Officers from the Hospital, and one Medical Officer (usually a Fleet Surgeon) from the ships or establishments.

They survey him and invalid him out of the Service. After the necessary papers have been signed he is discharged invalided and sent to his home.

Men on leaving are presented with a pocket spittoon and Form M 137 - General Directions to Consumptive Persons. The Medical Officer of the district is notified. Surveys take place once a month, but special surveys may be ordered.

Men about to be invalided are instructed to apply for Insurance benefits for consumptives under the new Act, and the necessary correspondence is undertaken by the hospital authorities. This is got in hand as soon as possible after the patient's admission, that there may be no delay when the man is discharged.

Men who refuse sanatorium benefits are discharged to their homes on being invalided. Men who accept can be retained in hospital if they wish, provided there is no undue delay and that there is accommodation for them.

Men invalided abroad are sent to the Home Hospitals and again surveyed there.

Pensions and gratuities are considered by the Admiralty and depend on the length of service, and whether the disease is considered to be attributable to the service or not.

C O N C L U S I O N.

To conclude, while we must admit that pulmonary tuberculosis is still a very common disease in the Royal Navy, and one that causes great loss to the Service of men, often highly trained and valuable men, yet all indications go to prove that it is on the decrease and that this decrease will be greater every year. The more careful examination of recruits, the early diagnosis and removal of foci of infection, and the greater resisting powers to infection produced by improved food and more hygienic surroundings must tell in the long run, and we can, I think, look forward with confidence to a time in the future when pulmonary tuberculosis will be one of the incidental diseases in the British Navy.

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