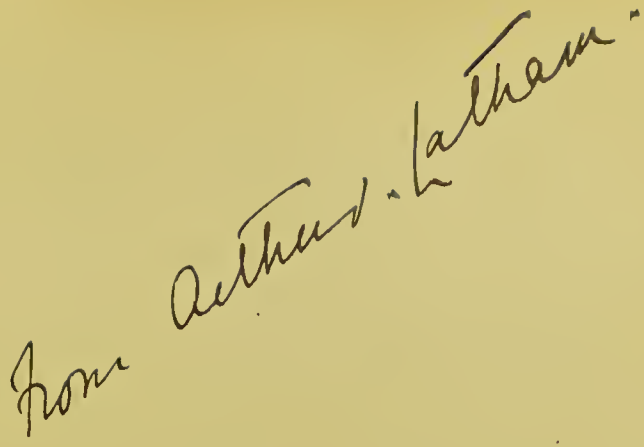
THE PRIZE ESSAY
ON THE ERECTION OF
"THE KING EDWARD VII SANATORIUM"
FOR CONSUMPTION

ARTHUR LATHAM
IN ASSOCIATION WITH
A. WILLIAM WEST



THE ERECTION OF A SANATORIUM

FOR

THE TREATMENT OF TUBERCULOSIS IN ENGLAND

THE PRIZE ESSAY ON THE

ERECTION OF A SANATORIUM

FOR THE TREATMENT OF

TUBERCULOSIS IN ENGLAND

TOGETHER WITH

A Preface by the Chairman of His Majesty's Advisory Committee, a Number of Appendices, Illustrative Plans, and a Bibliography

BY

ARTHUR LATHAM, M.A., M.D. Oxon., M.A. Cantab.

ASSISTANT PHYSICIAN AND LECTURER ON PRACTICAL MEDICINE AT ST. GEORGE'S HOSPITAL; ASSISTANT PHYSICIAN AT THE BROMPTON HOSPITAL FOR CONSUMPTION AND DISEASES OF THE CHEST; FORMERLY PHYSICIAN TO OUT-PATIENTS, VICTORIA HOSPITAL FOR CHILDREN, AND RADCLIFFE TRAVELLING FELLOW IN THE UNIVERSITY OF OXFORD;

IN ASSOCIATION WITH

A. WILLIAM WEST

ARCHITECT

HONORARY DEPUTY TREASUPER OF ST. GEORGE'S HOSPITAL

LONDON

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PREFACE

BY THE CHAIRMAN OF HIS MAJESTY'S ADVISORY COMMITTEE

I AM commanded by HIS MAJESTY KING EDWARD VII. to preface the publication of the Essays and Plans which were successful in the recent competition for the Erection of a Sanatorium for Tuberculosis by a brief explanation of the principles by which His Majesty's Advisory Committee were guided in the adjudication of the Prizes. It will be well, therefore, to reproduce the terms of the Advertisement announcing the Competition, which was issued in the medical papers in the first week of January, 1902 :

PRIZE ESSAY FOR THE ERECTION OF A SANATORIUM IN ENGLAND FOR TUBERCULOSIS.

HIS MAJESTY THE KING has graciously consented to direct that the Expenditure of a large sum of money which has been placed at his disposal for charitable or utilitarian purposes shall be devoted to the Erection in England of a Sanatorium for Tuberculous Patients.

His Majesty has appointed the following Gentlemen as an Advisory Committee for this purpose: Sir William Broadbent, Bart., K.C.V.O.; Sir Richard Douglas Powell, Bart., K.C.V.O.; Sir Francis Laking, K.C.V.O.; Sir Felix Semon; Sir Hermann Weber; Dr. C. Theodore Williams.

It is intended to construct the Sanatorium on the best lines which past experience and original thought can suggest, and in order to obtain the most valuable opinions His Majesty has been pleased to approve that a sum of £800 be awarded in Prizes for the best Essays and Plans which may be sent in to the Advisory Committee, under the following conditions:

1. Medical Men of all nationalities may compete. The Papers may either be the work of a Medical Man, or the joint production of a Medical Man and an Architect.

2. The Sanatorium is intended for 100 Tuberculous Patients—50 male and 50 female.

3. Of the total number of beds, 88 will be assigned to the more necessitous classes, whilst 12 will be reserved for the well-to-do.

4. The accommodation for all patients is to be comfortable, a separate room being provided for each. Superior arrangements to be made for the more wealthy patients.

5. It may be taken for granted that the Sanatorium will be erected on an elevated and sloping site, with a sunny exposure, and well sheltered from cold winds. It will have a Farm at a convenient distance, and be surrounded by extensive grounds, well-wooded, and affording ample space for exercises of various kinds. The soil will be dry and permeable, and the water-supply abundant.

6. The Sanatorium must be fitted with the latest sanitary arrangements, and equipped with all requirements for scientific research. Provision should also be made for the recreation of the patients.

7. Economy in construction will be an important consideration, but it must not interfere with the reasonable comfort of the patients or the efficiency of the Institution.

8. The Essays must be in English, and type-written.

9. The Essays must not bear the name or names of their Authors, but should have a Motto, and each Essay should be accompanied by a sealed envelope bearing the Motto on the outside and containing the full name and address of the Author or Authors inside.

10. All Essays and Plans must be sent, postage paid, on or before 15th April, 1902, to one of the Secretaries of the Committee :

Dr. P. HORTON-SMITH,
15, Upper Brook Street, W. London; or
Dr. J. BROADBENT,
35, Seymour Street, W. London.

11. Three Money Prizes of £500, £200, and £100 respectively, will be awarded, in order of merit, on the recommendation of the Advisory Committee, for the three best Essays, provided they come up to the requisite standard of excellence. Brevity will be an important consideration, and a summary of the main features of the scheme should be appended to the Paper. Unsuccessful Papers will be returned to the Authors.

This advertisement appeared in twenty-two medical papers in the Capitals of Europe and America.

The object of the Competition was to obtain information as to the relative advantages of the various structural arrangements which have been employed in existing Sanatoria, and to elicit new ideas which might be turned to advantage in the construction of 'The King Edward VII. Sanatorium' so as to make it as perfect as possible. The Essays were adjudicated according as they conformed in greater or lesser degree to these requirements. The number of Essays sent in was 180. They were carefully read, and were grouped into three classes, 'α,' 'β,' and 'γ.' Those in Class 'γ' were first eliminated, then those in Class 'β,' Class 'α' alone being retained. By a further process of selection the latter were narrowed down to twelve, from among which, by a unanimous vote of the Advisory

Committee, the three Prize-winners were finally chosen.

Immediately after the decision had been arrived at, the sealed envelopes containing the names of the authors, and bearing on the outside their mottoes, were opened by the Secretaries in the presence of the Committee, and the names and nationality of the writers thus disclosed.

The following is the list of the Prize-winners, and of four other competitors to whom Honourable Mention was awarded, the latter being placed in alphabetical order :

FIRST PRIZE :

Motto : 'Give him air ; he'll straight be well.'

Dr. ARTHUR LATHAM (London), *with whom was associated as Architect* Mr. WILLIAM WEST (London).

SECOND PRIZE :

Motto : 'If preventable, why not prevented ?'

Dr. F. J. WETHERED (London), *with whom were associated as Architects* Messrs. LAW and ALLEN (London).

THIRD PRIZE :

Motto : 'Vis medicatrix naturæ.'

Dr. E. C. MORLAND (Croydon), *with whom was associated as Architect* Mr. G. MORLAND (Croydon).

HONOURABLY MENTIONED:

(*a*) '𝔉ac recte, nil time.' Dr. P. S. Hichens (Northampton), *with whom was associated as Architect* Mr. R. W. Schultz (London).

(*b*) '𝔒pen air everywhere.' Dr. Turban (Davos), *with whom was associated as Architect* Herr J. Gros (Zürich).

(*c*) '𝔥onesta quam magna.' Dr. Jane Walker (London), *with whom were associated as Architects* Messrs. Smith and Brewer (London).

(*d*) '𝔥umus.' Dr. J. P. Wills (Bexhill), *with whom was associated as Architect* Mr. Wills (London).

With the approval of His Majesty, the result of the Competition was announced in the medical papers on August 8th, 1902.

(Signed) W. H. BROADBENT,
M.D., F.R.S.

London, *January*, 1903.

AUTHOR'S PREFACE

At the present day there is not complete unanimity with regard to the lines upon which the treatment of tuberculosis should be conducted in a sanatorium. As these differences of opinion necessarily affect the character of the sanatorium buildings, we thought it best to consider in the first instance the principles upon which the treatment of tuberculosis is based, and then to discuss the various questions involved in the erection and construction of the necessary buildings in which these principles may be carried out to the greatest advantage.

As one of our instructions was to the effect that brevity was an important consideration, our conclusions are somewhat dogmatically expressed ; but our opinions are based on a careful study of the whole of the extensive literature of the subject, and on information derived from personal visits to a large number of the principal sanatoria.

Equipment is only dealt with when it directly affects the construction or the character of the buildings required.

It was impossible in the time at our disposal to make the various Appendices complete, but they may be taken as being representative of past experience.

The Bibliography, which was added in the hope that it might be of some service to His Majesty's Advisory Committee, consists chiefly of references to books and articles on sanatoria and on the sanatorium method of treatment. No mention is made of the various articles in the numerous pamphlets issued by the British National Association for the Prevention of Tuberculosis, by the Œuvre de la Tuberculose, or similar societies in other countries; of the special periodicals devoted to this subject; nor of the reports either of societies such as the Hanseatic Insurance Company or of the large number of sanatoria now in existence, as these are well known. On such subjects as disinfection and the infectivity of dust, references have been given only to the more important and recent papers.

We take this opportunity of expressing our gratitude to a large number of friends for much kindly assistance, and of thanking the proprietors and the editors of the *Lancet* for their courtesy in connection with the publication of this essay.

ARTHUR LATHAM.
A. WILLIAM WEST.

LONDON, *January*, 1903.

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[1] See p. xv for list of these.

[2] See p. xvii for list of these.

ILLUSTRATIVE PLANS, Etc.

LIST OF APPENDICES

'Give him air; he'll straight be well.'

SHAKESPEARE: *King Henry IV.*

AN ESSAY

ON THE

ERECTION OF A SANATORIUM

FOR THE

TREATMENT OF TUBERCULOSIS

PART I

A DISCUSSION OF THE PRINCIPLES INVOLVED

HISTORICAL INTRODUCTION

TWENTY-FIVE centuries ago Hippocrates wrote that tuberculosis was a curable affection, provided that it was treated at a sufficiently early stage. Many of the ancient authors, such as Celsus, Pliny, Galen, and others, expressed similar opinions, and insisted on the importance of a suitable climate and good living. It was left, however, to a Scotch physician in 1747, when writing to his London friends, to assert for the first time in clear and unmistakable language, supported by the incontestable evidence of the results he had obtained, that hygiene and diet are the most important factors in the treatment of tuberculosis, and that climate and medicine are

Hippocrates.

Letter of a Scotch physician in 1747.

only to be considered as more or less precious adjuvants. The practical outcome of this teaching was not encouraging, and until some fifty years ago both the public and the overwhelming majority of the medical profession regarded tuberculosis as an incurable disease. So much was this the case that Sir T. Young, writing in 1815, said: 'Even with the utmost powers of art, perhaps not more than one case in a hundred will be found curable;' whilst Ullesperger called attention in 1867 to the fact that up to that time barely 200 cases of cured, or what we should now term arrested, tuberculosis were to be found in medical, as distinct from pathological, literature. A French writer took a more hopeful view when he said: 'There are two kinds of consumption—that of the rich, which is sometimes, and that of the poor, which is never, cured. The principles formulated by the Scotch physician were not readily appreciated, and were seldom put into practice, the efforts of medical men of that day being directed towards the comfort of their patients rather than the arrest of the disease. Thus, all tuberculous individuals, and even those who were regarded as being likely to contract the disorder, were wrapped up in heavy clothes, kept in a hot-house atmosphere, and jealously guarded against exposure to the fresh air.

Sir T. Young.

The great additions to our knowledge of the

pathology of tuberculosis, which originated in the genius of Laennec, paved the way for that radical alteration of the views held by the majority of physicians with regard to the curability and treatment of the disease, which was chiefly brought about by the teaching of Carswell. In 1836 this author wrote: 'Pathological anatomy has never afforded stronger evidence of the curability of a disease than in the case of phthisis.' This opinion has been supported by every subsequent observer. That this view was able to gain ground as rapidly as it did was due in no small measure to the establishment in England of special hospitals for consumption, namely, the Royal Sea-Bathing Infirmary for Scrofula at Margate in 1791, the Royal Hospital for Diseases of the Chest in London in 1814, and the Brompton Hospital for Consumption in 1841. Further progress towards a true conception of tuberculosis was made by Pasteur's creation of the new science of bacteriology, by Villemin's demonstration in 1865 of the fact that the disease can be transmitted to animals by means of inoculation, by Koch's announcement in 1882 of his memorable discovery that tuberculosis is an infective disease and depends for its inception upon a bacillus, and finally by Sir John Simon's classification in 1887 of tuberculosis as a filth disease.

Laennec.

Carswell.

Pasteur, Villemin, Koch.

The advance of our pathological knowledge during

recent years has made it possible to formulate the real principles upon which the treatment of this disease should be based, but we owe a deep debt to those members of the medical profession who from time to time during the last century made an effort, in spite of the contumely poured upon them by their fellow-practitioners, to carry out the treatment on the basis we now adopt. In 1840 George Bodington, of Sutton Coldfield, Warwickshire, England, wrote an essay on 'The Cure of Pulmonary Consumption on Principles, Natural, Rational, and Successful,' in which he insisted on the importance of a generous diet, fresh air day and night, 'together with systematic arrangements with regard to exercise and general treatment, and the watchfulness daily—nay, almost hourly—over a patient of a medical superintendent.' Bodington emphasized his views on the necessity of a continuous supply of fresh air by this sentence: 'Cold is never too intense for a consumptive patient; the apartment should be kept well aired, so that it should resemble the pure air outside, pure air being used in the treatment as much as possible.' This author met with the most bitter and contemptuous treatment, being regarded as a lunatic; his patients were driven from his institution, which by the irony of fate he was compelled to turn into an asylum for the reception of the insane. His sanatorium was the first of its kind in the world, and

Bodington.

within its walls, for several years previous to the publication of his essay, Bodington had practised his principles and effected many cures. In 1855 Dr. Henry McCormac of Belfast published a book on somewhat similar lines, and as a result had to bear every kind of persecution to which a man in his position could be subjected. In 1861 he read before a distinguished medical society in London a paper on The Absolute Preventability of Consumption, in which he advocated what are now established principles. Practically the same doctrine was preached at this time by Bennett of Mentone and by the late Sir Benjamin Ward Richardson, who embodied his views in a pamphlet called 'A Sanitary Decalogue.' The man, however, who must be regarded as the founder of the sanatorium treatment of tuberculosis is Hermann Brehmer, for he persisted, in spite of fierce opposition and oftentimes abuse, in his methods, which were more systematic and thorough than those of his predecessors, and he finally convinced the world of their soundness and importance. Brehmer's thesis for his final degree (1856), 'Tuberculosis primis in stadiis semper curabilis,' was characteristic of his life's work. In 1859 he was permitted, owing to the influence of his friends Humboldt and Schönlein, to open a sanatorium at Görbersdorf, and in 1886 he published his well-known book.

McCormac.

Hermann Brehmer.

General acceptance of Brehmer's views did not come at once; indeed, some of the grounds upon which they were based have since been shown to be erroneous. His supporters met with little encouragement, and not infrequently with reproach; but it is owing to them, to such men as Rohden, Dettweiler, and Otto Walther in Germany, Sir Hermann Weber in England, and Blake and E. L. Trudeau in the United States of America, that we have at last come to regard the open-air sanatorium treatment as the best remedy for tuberculosis.

Brehmer's views.

Brehmer held that tuberculosis was an infectious disorder, but that certain conditions, more especially a small heart, made people much more liable to it. He noticed that at Görbersdorf there was hardly any tuberculous disease, and that the inhabitants had peculiarly powerful hearts. These facts, he thought, were due to the air pressure at the altitude of that place. He not only adopted Küchenmeister's theory that tuberculous disease did not exist above a certain altitude, which increased as the equator was approached, but supposed that the diminution of air-pressure increased the power of the heart, and so lessened the liability towards tuberculous infection. His next step marked a great advance, for Brehmer argued that 'anything which protects one man from falling ill must be able, if properly employed, to cure another of the same disease,' and

from this argument he evolved the modern treatment of tuberculosis on the following lines :

The essential principles of Brehmer's treatment.

1. A LIFE SPENT IN THE OPEN AIR UNDER CONDITIONS WHICH GIVE IMMUNITY FROM TUBERCULOSIS.
2. COMPLETE FREEDOM FROM ANY DEBILITATING CIRCUMSTANCES OR ANYTHING WHICH MAY LEAD TO AN EXACERBATION OF THE DISEASE.
3. METHODICAL HILL-CLIMBING AS AN EXERCISE WHEN THE CONDITION OF THE PATIENT RENDERS THIS ADVISABLE.
4. AN ABUNDANT DIETARY IN WHICH MILK, FATTY FOOD, AND VEGETABLES OCCUPY AN IMPORTANT PLACE.
5. VARIOUS HYDRO-THERAPEUTIC MEASURES.
6. CONSTANT AND UNREMITTING MEDICAL SUPERVISION.

Consideration of Brehmer's essential principles.

Brehmer also insisted on the necessity of providing facilities both for observation and research. These headings might stand fairly enough to-day. In the nature of things, they tend to overlap one another, but it will probably conduce to brevity if we discuss them separately, first of all examining the scientific grounds upon which they rest at the present time, and then drawing our conclusions as to what requirements they necessitate in the shape of buildings.

1. A Life Spent in the Open Air under Conditions which give Immunity from Tuberculosis.

Conditions for immunity.

The idea that at a certain altitude there exists a zone free from tuberculosis was shown by Dettweiler and others to be erroneous, for tuberculous disease was found to be rife amongst the watchmakers in the High Alps, whilst it does not exist in the Khirjis Steppes, which are below the sea-level, nor in the low-lying portions of Iceland. The keynote of Brehmer's treatment was not, however, a question of altitude or climate, but conditions which insure exemption from tuberculosis. He was wrong in thinking that these conditions could only be obtained at high altitudes; in fact, the observations of Finkelnburg and others have shown that the really essential climatic conditions for sanatorium treatment are those expressed in our instructions.[1] Brehmer was right, however, in thinking that tuberculosis could only be satisfactorily dealt with when the conditions under which the patient lived were identical with those which had kept others free from the disease. In 1855, when he first acted on the above ideas, our pathological knowledge on the subject was far from perfect, and he could not have possessed very exact

[1] 'An elevated and sloping site with a sunny exposure well sheltered from the cold winds. A dry and permeable soil, together with an abundant supply of water.'

information with regard to the etiology of tuberculosis. Owing to the rapid strides made by pathology and bacteriology, and especially to the discovery in 1882 by Koch of the tubercle bacillus, our knowledge, though still imperfect, is much more exact and extensive.

Conditions of infection.

We know now that tuberculosis depends upon infection with the tubercle bacillus, and that this does not and cannot take place unless a man happens to be susceptible, or, to put it in other words, unless what we call, for want of a better term, his vitality has been so lowered by his surroundings, by disease, or by the quality and quantity of his food, that he is powerless to resist infection although previously immune. Anyone who has contracted tuberculosis shows thereby that his resistance has been lowered, and that it is necessary for him to be protected from any source of further infection, more especially as we have no guarantee that he may not be further infected by tubercle bacilli of greater virulence than those which have already established a hold upon him. It has been shown that the form of treatment which does this most effectually, in the greater number of cases, is that carried out in a sanatorium conducted on open-air lines (see Appendix No. II., p. 152). Before, however, we can discuss the character of such an institution, we must consider in greater detail the various questions raised by the etiology of the disease.

Infection by expectoration.

Koch, in 1882, showed that tuberculous disease depended upon infection with tubercle bacilli. These micro-organisms are contained in the expectorated mucus or phlegm of tuberculous individuals; and the one subject upon which there was complete unanimity at the late Congress in London, was that tuberculous sputum is the most potent factor in the spread of infection. It is true that infection may arise from tuberculous disease of other organs or parts of the body than the lungs, but the spread of infection from these sources is not so great as in the case of pulmonary consumption, although it follows the same lines. The bacilli are not, as a rule, contained in the breath, because the air in passing over the mucus attached to the walls of the bronchi does not carry off these micro-organisms. It has, however, been shown by Fraenkel, and especially by Flügge and his pupils, that in certain instances, when tuberculous persons cough violently or splutter whilst speaking, small particles of phlegm are carried off with the breath, and so become the source of infection.

Conditions for direct infection from a consumptive individual.

Flügge and Latschenko requested some consumptive patients to cough, but not to expectorate, in a large glass box. The patients had to wear new rubber coats and rubber shoes, in order to avoid any sputum being detached from their clothes, and so leading to error. Sterilized glass plates some-

what moistened were previously placed in the upper portion of the glass box. After the patients had coughed, the expectorated material was scraped off these plates and inoculated into animals. All these animals developed tuberculosis. Somewhat similar results have been obtained by Boston. These experiments, taken in conjunction with Hiller's calculation that there may be as many as 100,000,000 tubercle bacilli in each cubic centimetre of sputum, show that consumptive patients may be a source of danger to those in their immediate vicinity, not only when they cough, but also in certain cases, when they speak. As we shall presently see however, this danger can, practically speaking, be averted by the adoption of suitable precautions. The small particles of sputum may float in the air for fifteen minutes to one and a half hours, and whilst they are floating in the air they may readily affect individuals who, so to speak, come within the line of fire. Thus, Cornet has shown in his classical work that guinea-pigs become tuberculous when made to inhale moist air containing tubercle bacilli ; and Flügge, working recently on the same lines with the *Bacillus prodigiosus*, showed that cultivations of this micro-organism could be grown from the smaller bronchi of the animals exposed to the spray, provided that the animals were killed and dissected within half an hour of the experiment.

Infectivity of dust.

After these particles have floated in the air for a varying time, they gravitate towards the ground, and in doing so infect everything, such as furniture, books, and the like, upon which they happen to fall. Consequently the dust taken from the houses inhabited by consumptive individuals has been shown by numerous observers to be infective. Cornet, who has been confirmed by Biggs of New York and others, showed that dust purposely collected from the wall behind the bed of a patient, or from the rails of the bed behind the patient's head, where there was little likelihood of direct infection by coughing, and dust from tops of pictures, from cornices, and from the floor, when injected into guinea-pigs, caused tuberculosis, unless the patient had taken strict precautions about infection. Coates of Manchester showed that, of dirty houses occupied by consumptive persons, at least 60 per cent. yielded infective dust, and that in the case of clean houses no less than 50 per cent. contained contaminated material. He, in fact, proved that ordinary cleanliness alone was not sufficient to prevent the accumulation of infective material in rooms occupied by a consumptive person. We see then, that such an individual may infect the dust and furniture of his room. It has also been clearly shown that he frequently infects his clothes. Cornet completed our knowledge of the part played in

infection by the tubercle bacillus when he showed conclusively that guinea-pigs may readily be made tuberculous when they are exposed to an atmosphere containing *dried* tuberculous sputum, and that moisture is not an essential factor. Again, Spillman and Haushalter of Nancy have shown by extensive experiments that the common house fly may become the propagator of tuberculosis by acting as a carrier of tuberculous dust.

The part played by clothes.

Probably, then, consumptive persons infect dust, and this, on being scattered, infects other people who are in a condition to contract the disease. Brehmer, indeed, held that this infection by dust was chiefly by bed-clothes, ordinary clothes, and, above all, by handkerchiefs. Every motion of the clothes causes little pieces of fibre, hair, and the like, to break off, and it is through this fine dust, rather than the dried sputum on the floor, which breaks into larger fragments, that infection takes place.

How to avoid these modes of infection.

The danger of infection by these means is a real one, but it may readily be reduced to a minimum. Both Latschenko and Heymann have shown that for infection to take place in this way a close proximity to the patient is essential, and that the infected particles are never projected beyond a distance of from 3 to 5 feet. Heymann (1901) has, moreover, ascertained that the *maximum*

distance is reduced to 3 feet if the patient holds a handkerchief in front of his mouth when coughing. Flügge (1901) states that the air of a tuberculous patient's bedroom is not often infectious, and that the floating dust, to be dangerous, must be present in clouds, as is the case, for example, in factories, or when rooms are swept. The danger is still further reduced inasmuch as many consumptive individuals have no tubercle bacilli in their phlegm, and still more have none in their saliva, whilst most patients at a sanatorium rapidly lose their cough. That the adoption of reasonable precautions with regard to the sputum practically does away with the danger of infection by these means, has been conclusively shown by the well-known observations and experiments upon the spread of infection in institutions for consumptive patients carried out by Cornet, Cotton and Theodore Williams, Heron, Hance, Achtermann and others. It is on such precautions that we must rely rather than on antiseptics or isolation. We have learnt, in fact, that, as in surgery so in tuberculosis, asepsis rather than antisepsis affords the best means of preventing the spread of infection. To give one example : Bryce showed by means of certain experiments that no tubercle bacilli could be found on the hands of eighteen sanatorium patients who used pocket-flasks but no handkerchiefs, whereas the hands of ordinary

consumptive patients who used handkerchiefs were infective in no less than eight out of ten cases.

Conclusions to be drawn from a consideration of the modes of infection.

Koch and others have shown that it is extremely rare for tuberculosis to be hereditary—that is to say, for the tubercle bacilli to be handed down directly from parent to child. The chief source of infection, then, apart from the question of infection by milk and food, which we shall briefly discuss later, is dust which has been infected by tubercle bacilli. It is clear that those precautions, such as the collection and destruction of sputum, which have been proved to be efficacious in preventing the dust from becoming infected must be adopted in any institution for the treatment of tuberculosis. As, however, patients may in an unguarded moment, or from neglect or accident, disseminate the bacilli, a sanatorium for tuberculous individuals should be constructed and equipped in such a way that the dust which inevitably collects can be readily removed. Further, every precaution should be taken against the formation of dust anywhere in the vicinity of a sanatorium, not only because such dust may become infective, but because both dust and organic effluvia lead to bad results. The former excites useless cough and irritates the air-passages, while the latter lowers the constitutional vitality, and, as we shall see, fosters the growth of the tubercle bacillus. The grounds should therefore be laid out in such a way

that the possibility of dust being carried by the wind is minimized; again, coal, that most potent factor in the formation of dust, should be used as sparingly as possible, and if used at all should be consumed as completely as may be, whilst the buildings should be well removed from roads and from human traffic.

Conditions which lower an individual's resistance to tuberculosis.

It is generally accepted that tubercle bacilli are harmless for those in a good condition of health—for those, that is, whose resistance has not been so reduced that they readily fall a prey to disease. We must consequently consider what circumstances lead to a diminution of resistance, in order that we may be in a position to avoid them in the erection of our buildings. Long before tuberculous disease was regarded as infectious, evidence was being accumulated to show that bad sanitary conditions, such as absence of sunlight or ventilation, bad drainage, and polluted subsoil, together with an insufficient supply of food, were the chief predisposing causes of consumption. The fact that insufficient or unnutritious food plays an important part in the etiology of tuberculosis rests on the firm foundation of our knowledge with regard to the etiology of nearly all diseases. 'Where the Sun and Air do not enter the Physician enters often' is an old Persian proverb, whilst the sanitary records of the last sixty years, and the extraordinary diminution in the rate

of mortality from tuberculosis which has followed the adoption of better sanitary conditions, prove that close confinement and bad ventilation are among the most important factors in the etiology of this disease.

Effects of confinement.

One or two examples of the effect of confinement and bad ventilation will suffice. Cornet, in investigating the statistics of the mortality from tuberculosis in females, came to the conclusion that in sisterhoods where the above bad sanitary conditions obtain, a healthy girl entering at seventeen dies 21·5 years earlier than her sister who belongs to the general population of the State; that such an inmate in her twenty-fifth year has the same expectation of life as a female of the outer world at the age of forty-five; and that a nun of thirty-three must be classed with a female outside at the age of sixty-two. The same is true of animals, as Sir F. Fitzwygram has shown in connection with the London cab-horse, and as is well exemplified by the fact that, whilst horses at one time died in large numbers from tuberculosis in the London Wellington Barracks owing to bad ventilation, yet very few died in the Crimea from this cause, although they were constantly exposed to the effects of a rigorous climate. It is, in fact, now regarded as a law, that where there is a high mortality from tuberculosis the sanitary conditions are imperfect.

On what do these effects depend?

The bad effect of close confinement and insufficient ventilation is due to the impurity of the air, to what has been called air sewage. Ehrenberg and many others have shown the enormous quantity of floating matter which exists in impure air, and Pasteur laid it down as a law that air to be pure must be free from both organic and inorganic floating matter. Haldane and Lorrain Smith have shown that in respired air the only deleterious substance, apart from micro-organisms, is carbon dioxide gas, and it is an established fact that when this gas becomes appreciably increased over its percentage in the outside air the health suffers and the resistance of the body is impaired. In addition to the excess of carbon dioxide present in the air of badly-ventilated rooms, we must mention the organic matter contained in the dust, the sulphuretted hydrogen and other gases given off from drains, from kitchen traps, and from insufficient coal decomposition, and, most important of all, the various forms of micro-organisms which are constantly to be found. Many of these micro-organisms, such as the varieties of streptococcus, not only lead directly to disease, but are the cause of secondary infection in tuberculosis. We have said enough then, to show that the most powerful predisposing cause of tuberculosis is foul air, and that, as Lord Beaconsfield once said, the atmo-

sphere in which we live has more to do with human happiness than all the accidents of fortune and all the acts of Government.

How to avoid these effects.

Numerous observations by Angus Smith, Pettenkofer, and Moeller have proved that it is very difficult to maintain the ventilation of any building at such a pitch that the air contained within it has the same composition as pure outside air. Pettenkofer, in his work on this subject, has shown that in the open 324,000 cubic feet of air pass over an individual in an hour under ordinary conditions, and that we cannot approach this amount in any building. Again, ozone is obtained only in the outside atmosphere. Many virtues are attributed by some authorities to this gas, but it is doubtful whether its presence has any value save as an index of the atmospheric purity. In any case, Delépine has shown that ozone has no effect upon the virulence or life of the tubercle bacillus. We may conclude that our first aim must be to provide such ventilation that the air contained within our buildings does not essentially differ from the outside air. It has, indeed, been said that it is as unreasonable to ask people to breathe air which has already been respired and contaminated as to ask them to wash in water already used by others.

Foul air not only lowers our power of resisting disease: it also favours the growth of the tubercle

Conditions inimical to the growth of tubercle bacilli.

bacillus. Koch, Arthur Ransome, Cornil, and others, have clearly demonstrated that under the influence of darkness, and in the absence of any movement in the air, tubercle bacilli may thrive and remain virulent for many weeks and even months, in the corners of a room, under beds, and behind articles of furniture, provided that the air contains a sufficient quantity of aqueous vapour and organic matter. Free ventilation, according to these authors, even in the dark, has the power of arresting the virulence of the bacillus provided there is no great excess of organic matter. Sawizky, however, asserted in 1891 that mere drying of tuberculous sputum induces only a gradual decrease of virulency, and that in ordinary dwelling-rooms dried sputum will retain its infective power for two and a half months. It is known that diffuse daylight will cause the death of the tubercle bacillus in time, but this is most readily accomplished by free ventilation and direct sunlight. Ransome, who states that the bacilli may grow at the ordinary temperature on damp wall-paper, has shown that under the healthy conditions of dry, pure subsoil, good drainage, free ventilation, and plenty of sunlight, the tubercle bacillus loses its virulence so rapidly that tuberculous sputum loses its infective power even before it becomes dry and is converted into dust.

Beneficial effects of an open-air life.

We see, then, that the best conditions, not only for preserving and strengthening the resistance of the body to the inroads of the bacillus, but for the ready destruction of the tubercle bacillus itself, are obtained by an open-air life. Further, an open-air life must do much to starve out those micro-organisms, such as streptococci, which so materially assist the tubercle bacilli. Brehmer, following in Bodington's footsteps, grasped this truth before Koch demonstrated the infective nature of the disease, and as he argued that the circumstances which kept a man free from tuberculosis must be the ideal ones for those already afflicted, he insisted on the importance of consumptive persons, and others suffering from tuberculosis, living as far as possible in the open air.

Exposure no drawback.

The great objection to Brehmer's views which was raised by medical men of his own time, and, indeed, by many at the present day, was that patients, especially delicate people suffering from consumption, could not stand the necessary exposure. It had, however, long been known that tuberculosis runs a relatively rapid course in warm climates, and that patients who gained weight and improved in health during the winter lost ground as soon as the warmer weather set in. Again, the health resorts which were most successful in the treatment of consumption, almost without exception, had been places which

were cold, or at all events cool, during some part of the twenty-four hours. These facts, and the knowledge that animals with incipient tuberculosis recovered when they led an open-air life, whereas they died if kept to the house, furnished strong support to Brehmer's views. Our experience for the last forty years has done much to strengthen the position taken up by him. It has been found by experience that no amount of exposure to wet or any variation of temperature causes the most delicate patient to contract what is termed a chill, or to suffer any other harm, so long as an open-air life is led and the exposure is constant. If patients are well nourished, sufficiently clothed, and sheltered from the wind, any degree of cold may be defied. At Falkenstein, for example, patients lie out of doors for many hours during thick fog and snow-storms, and when the temperature is 10° to 12° C. below freezing-point. Blumenfeld made an elaborate investigation of the harmful effects due to meteorological conditions at Falkenstein, but found that these occurred only when north-east winds were prevalent. Andrord of Tonsaarsen, Norway, keeps patients five to nine hours a day in the open air at a temperature of — 25° C. without any bad effect. The same extreme cold is safely endured at the Charon Sanatorium near Boston and the Chestnut Hill Hospital near

Philadelphia. Were fine weather and freedom from exposure a *sine quâ non*, the remarkable success of the sanatoria in the Black Forest, more especially of the Nordrach Colonie, and the favourable results recorded by Josselin de Jong with regard to low-lying districts in Holland, would never have been chronicled. The sanatoria of the Black Forest have a moist and chilly climate during part of the year, but patients do at least as well at such seasons as in finer weather. Indeed, the results of treatment are better in winter than in summer. This was first pointed out by Grabilowitsch of Halila, and has been confirmed by several Continental authorities; in fact, no one claims to have better results in summer. That this is true, not only of foreign sanatoria, but of sanatoria in England, is seen in Appendix No. III., p. 156, where it is shown that in many cases the results are better in the winter months than in summer. In some institutions, such as the Victoria Hospital, Edinburgh, and the hospital at Bridge of Weir in Scotland, heated air was at first employed; after a fair trial of this method Brehmer's plan of constant exposure to the temperature of the outside air was adopted, and much better results were obtained. Again, it has been found that patients readily become acclimatized to exposure. In fact, the circulation in their extremities is so much improved at the end

of a week or two in an efficient sanatorium that they cease to ask for hot bottles for their feet, whilst they develop such an 'air-hunger' that they refuse to go into rooms in which the windows are not kept constantly open. Two further great advantages of an open-air life are the remarkable way in which it stimulates the capricious appetite of the patients and the beneficial effect it exercises upon various forms of distressing cough.

Exposure, when constant, does not lead to rheumatism.

It has been objected that patients may lose their tuberculosis in this way only to contract rheumatism. A personal experience may be of interest on this point. One of us used to suffer so frequently from rheumatic pains that he took great care to avoid any possible draught, and to keep as far as possible at the same temperature. Some years ago he had occasion to spend a few weeks at Nordrach Colonie at a most inclement season. He followed the routine of the patients, and sat, often for hours, bare-headed and with no great-coat amidst the snow. He felt so much better in health that, on returning to his ordinary life he adopted the Nordrach methods to a large extent, and as a result has since been absolutely free from rheumatism.

Conditions for exposure.

We may say, then, that there is no danger from *constant* exposure in the climate of England. The patient needs pure air in all its natural simplicity. He must live in it, bathe in it continually. Discre-

tion must naturally be used. Thus many patients, especially those with extensive disease, cannot stand exposure to wind, and what is good at twenty-five years of age is not necessarily good at fifty-five. In extreme cold it is not always wise to have the windows widely open, as the cold air of winter circulates much more quickly than the warm air of summer. When the weather is extremely cold the patient's rooms may be slightly heated, and an attendant, on calling the patient in the morning, may close the window for him, so that he may avoid running the risk of getting out of a warm bed and dressing in a chilly atmosphere. The attendant may also close the window in cold weather before the patient returns from his walk, or at bedtime, and thus warm the room ; but the patient must invariably open the window when he comes in, for his life, not only when in a sanatorium, but ever afterwards, depends on his being hardened and on his becoming habituated to an open-air life of every and any degree of inclemency.

Conclusions.

It has been shown, then, that exposure to ordinary climatic conditions is no drawback to the treatment of consumption on open-air lines, and that pure air is, from the point of view both of prophylaxis and of treatment, of the utmost importance. In what way may the air become contaminated ? We have already seen that overcrowding, insufficient sunlight

and the absence of ventilation, are the most potent factors. The buildings, then, of a sanatorium must, as we have said, be so constructed that the atmosphere within them rivals the outside air in point of purity. For example, the smell of cooking destroys the appetite of an invalid, while fresh air stimulates it; consequently, great pains must be taken to completely shut off the dining and kitchen arrangements from the patients' rooms. Again, though it may be possible to keep a room where a single patient lies fairly free from impurity, the atmosphere of any room in which a number of people are gathered together for any length of time will certainly become more or less contaminated, and on this account alone it is obvious that the use of recreation-rooms or other places of assembly, such as churches, must be restricted within narrow limits. Finally, the sanitation must be perfect and without flaw.

We are now in a position to say that, in erecting a sanatorium, arrangements should be made of such a kind that—

1. The buildings are so situated, and of such a nature, that the formation of all dust is, as far as possible, avoided.
2. The dust, which inevitably collects, can be readily removed.
3. All infected material can be readily and effectually destroyed or disinfected.

4. The atmosphere of the buildings is free from all source of contamination, and rivals the outside air in point of purity.
5. The number of recreation-rooms and other places of assemblage is limited, and everything avoided which is calculated to tempt patients to stay indoors.

2. Complete Freedom from any Debilitating Circumstance or anything which may lead to an Exacerbation of the Disease.

We have seen that even in health various circumstances may so lower the resistance of the body that disease is contracted, and it is obvious that in the case of a man who is already debilitated by the ravages of tuberculosis many things which in health are possibly of little importance may cause a further loss of resistance, and so lead to an exacerbation of the disease. Tuberculosis is a febrile disease in most of its stages, and it is only during the last fifty years that we have learnt how small an indiscretion may lead to an increase of fever. In the treatment of this disease one of our main objects must be to maintain the temperature of our patients at a normal level. Anything which increases the fever or leads to the exhaustion of the patient assists the progress of the disease. All forms of excitement, whether mental or physical, encourage and intensify tuber-

culosis, whilst, as we shall see, nothing is no harmful as over-exertion of mind or body. *Everything which may lead to an exacerbation of the disease must be avoided, so that the damaged tissue may have time to heal*, and it must be constantly borne in mind that in a sanatorium the chief consideration is the recovery of health. For tuberculous individuals and their advisers this is a sufficiently difficult matter, and one to which everything else must be subordinated.

Aggregation of the sexes.

What dangers, then, beyond those already mentioned, must be avoided in the erection of a sanatorium? To take the question of the aggregation of the sexes first. There can be no doubt that patients who have comparatively little to occupy their minds, and who in many cases are of an erotic temperament, must be liable to considerable sexual temptation at a sanatorium. In our visits to sanatoria we have observed much which confirms us in this opinion, and the same conclusion has been formed by others. The sexual excitement which is engendered by such temptation is in most cases fatal to the progress of recovery, and, without labouring the point, we are convinced that the individual bedrooms of the two sexes should be separated as much as possible, in order that this source of temptation may be removed as far as may be. In certain sanatoria, as at Hauteville, the sexes are kept apart; at others, as at Oderberg and Glückauf,

separate establishments are provided. There is, however, no reason why the sexes should not mix in the dining-room and in their daily life. It has been found that this not only does no harm, but that in many cases it is productive of very good results.

Visitors. A more difficult point is the admission of visitors to the sanatorium. It has been argued that the absence of friends may depress the patient, and so retard recovery; but in those sanatoria in which visitors are to all intents and purposes excluded it has been found that distress at the absence of friends, though often marked when the patient arrives at the institution, rapidly wears off. On the other hand, it has been found that visitors do not readily accustom themselves to the necessary conditions, such as the ventilation, and that they often stir up trouble though their intentions may be of the best. Anyone familiar with disease knows what an effect the visits of friends may have upon patients. It is true that in some cases the temperament is phlegmatic, and no harm results; but in others the excitement consequent on receiving friends may lead to very grave results. It has been shown that the results obtained by treating consumptive patients at home are not to be compared with those obtained by the strict discipline of sanatorium life. Further, visitors to a sanatorium may introduce the germs of influenza or other debilitating disease, and

Sir William Broadbent has expressed the opinion that the visits of friends should be restricted as far as possible, and that all visitors should be received in the open air. We may conclude then that, in a sanatorium, the more restricted the accommodation for visitors is the better, as their absence seldom leads to harmful results, whilst their presence is often injurious. Gerhardt has put this in other words: 'Few people die of disappointment, but tuberculosis is a grave disease.'

Amusements.

Turning to the question of amusements, we may say at once that it is only within recent years that the majority of the medical profession have learnt the great injury which may result in the case of tuberculous patients from free indulgence even in such apparently trivial amusements as games of cards. We have known a patient, in whom the disease was apparently quiescent, develop a temperature of 102° F. entirely from the excitement of a too animated game of bridge. In many others playing the piano or taking part in theatricals has caused a considerable rise in temperature, and done much to retard recovery. Brehmer experimented upon himself with regard to the effect produced by card-playing on the metabolism of the body. He weighed himself after supper, and again two and a half hours later, hours spent in reading or chatting, and in this way ascertained the variation of body-weight under

normal conditions for a week. He then played a game of cards for very small stakes every evening for another week, and found that on the evenings on which he played cards he lost twice as much weight as on the other days. These experiments merit repetition, but experience supports Brehmer in his assertion that even card-playing may, in many cases, lead to bad results. Further, the temperature of excitable persons not infrequently is raised by reading inflammable literature, and it has been found by experience that the reading of many patients requires supervision. Amusements, such as billiards, golf, and others, which necessitate exercise, will be considered in the next section.

Whilst it is true that certain amusements do harm in many instances, it is nevertheless the fact that certain patients are benefited by being allowed to indulge in them. If, however, some patients are allowed too great freedom, and others are restricted, our experience, based on an intimate knowledge of many sanatoria, is that the discipline suffers, and that those whose liberty is curtailed become restive. *Again, anything which encourages aggregation or remaining indoors must be avoided.* The decision in all cases of what amusement may be allowed must be left to the physician. When patients understand that indulgence of any kind retards their recovery, they readily adapt themselves to the necessary discipline.

The absence, however, of all amusements of any kind leads to ennui, and, in the experience of all physicians, anything which causes depression of spirits is injurious owing to the influence of the mind upon the body. Consequently, all that tends to make the patient happy and cheerful should be permitted; all that is cheerless and depressing should be banished from his surroundings, whilst the greater number of amusements of a harmless kind the better, such for instance, as the art of photography or the science of botany. A library is essential. It has been found that occasional short entertainments are productive of nothing but good; those patients who are about to leave the sanatorium may play the piano for the others, or short concerts or theatrical entertainments may be got up, not by, but for, the patients from time to time. We see, then, that in the erection of a sanatorium the presence of a single recreation-room which allows of the entertainment of the patients under open-air conditions may be an advantage.

Heating and draughts.

Amongst other debilitating circumstances, we may mention exposure to draughts or to unnatural changes of temperature, such as are experienced when a patient goes from a hot room to a cold passage or gets into a cold bed. A sudden change of external temperature or exposure to a draught frequently gives rise to an attack of bronchitis or

other disease, which tends to retard recovery in tuberculosis. In other words, sudden alterations of temperature or exposure to a draught lower the resistance, and give micro-organisms their opportunity for starting some complication, such as a cold or an attack of pneumonia. These micro-organisms are banished from efficient sanatoria, and so colds do not occur. It is perfectly true that anyone may be hardened by exposure, and so may not contract disease under conditions which would kill a man brought up on hot-house principles; but the fact remains that sudden variations of temperature—not the variations due to the alterations in the weather, for these are not sudden in the sense we are using the word—and draughts lower the resistance, therefore they cannot be of service to consumptive patients and should be avoided, although the harm they may do may not be very apparent. We may say, then, that any heating arrangements must be of such a character, and the temperature reached of such a height, that no sudden variations can occur; that every precaution to prevent chilling of the patient should be taken, such, for example, as the use of sheets of a mixture of wool and cotton, for these are worse conductors and less cold than linen; and that draughts should be avoided, as they readily may be by making the inlet and outlet for the ventilation sufficiently large. Precautions must also

be taken to prevent any diminution in the humidity of the air owing to the heating apparatus.

Exposure to winds.

One more debilitating influence may be mentioned. Blumenfeld and others have shown that exposure to winds, more especially to cold winds, is injurious, and the conclusions of these observers are borne out by the experience of all sanatorium authorities. The injurious effect of wind is due to two causes: first, the dyspnœa it excites; and, secondly, the loss of heat which occurs in consequence of the great amount of air that passes over the body. The site of the proposed sanatorium is to be well sheltered from cold winds, but in addition, both in the grounds and in the buildings, protection should be afforded by artificial and natural shelters against any excess of wind.

Exposure to the sun.

The sun is an amenity and a cordial, and Rienzi has shown that it lengthens the lives of animals inoculated with tuberculosis; yet too great exposure to it is debilitating, and, according to some authorities, leads in certain cases to hæmoptysis. Consequently, measures must be taken for protection against the sun in hot weather.

Conclusions

We may conclude that in a sanatorium—

1. The bedrooms of the individual sexes should, as far as possible, be in separate blocks.
2. The accommodation for visitors should be strictly limited.

3. No special provision should be made for exciting amusements, but a well-stocked library and other forms of harmless recreation should be provided.
4. The means of heating employed should be easily regulated, and of such a kind that they do not interfere with the humidity of the air.
5. Although there must be free circulation of air, draughts should not be encouraged.
6. Efficient shelter should be provided against wind, sun, and heavy rain, not only in the sanatorium itself, but in the grounds.

3. Methodical Hill-climbing as an Exercise when the Condition of the Patient does not necessitate Repose.

The heart in tuberculosis

Brehmer, as has been said, observed that the inhabitants of Görbersdorf had powerful hearts and were free from tuberculosis, whilst tuberculous patients had small hearts and large lungs, and he came to the conclusion that anything which helped to strengthen the heart not only tended to ward off the disease, but was a most hopeful method of treatment. Baudement and Nathusius had shown that in many animals, such as oxen, the lungs and heart are in proportion to the body-weight. In other words, the greater the body-weight, or the more the

animals have eaten, the larger will be the heart and the smaller the lungs. Brehmer argued that many tuberculous patients, who nearly always have poor appetites at the growing period of life, have large lungs and small hearts in consequence of their low body-weight. Other observers, such as Rokitansky and Andral, and more recently Hutchinson, support Brehmer in this view. On the other hand, some authors, amongst whom may be mentioned Meissen, deny that a small heart is at all common in tuberculosis. Whether this be so or not, it is at least certain that the heart is distinctly enfeebled in this disease, and Leyden, Strumpell, and others have shown that partial atrophy of the cardiac muscle is not at all infrequently met with, so that there can be little doubt that anything which tends to increase the cardiac power is of value in the treatment of the disease. Von Ruck further holds that it is necessary to increase the power of the heart in tuberculosis of the lungs, in order that this organ may be able to deal with the pulmonary obstruction caused by the disease. Brehmer, in accordance with his own views, insisted on his patients taking gradual and slow uphill exercise whenever this could be done without producing fatigue or other unfavourable results, and this method of treatment is followed in many sanatoria at the present day. He held, however, that in many cases the exercise must be extremely moderate in amount, and, indeed, must

often be replaced by entire repose—that is, repose both of mind and body—a condition which can be obtained only by more or less complete isolation.

Dettweiler's modification of Brehmer's treatment.

Dettweiler, however, introduced a modification of Brehmer's ideas, and substituted rest in Liegehalle, or verandas, in place of uphill exercise, in the majority of cases. These two systems necessitate a different class of building, and we must therefore discuss the questions involved a little more in detail. All sanatorium authorities agree that under certain conditions rest in isolation is necessary for consumptive patients. Such conditions constantly arise even in institutions restricted to patients in the very early stages of the disease. We, however, take it for granted that in the case of the proposed sanatorium patients will be admitted in every stage of the disease which is likely to derive benefit from this form of treatment. We conclude that it is the gracious intention of His Majesty to found the sanatorium on model lines, so that the institution may not only be of service to the patients treated, but of educational value to the world at large. There can be no doubt that the earlier stages benefit more than the later ones, but, on the other hand, improvement or arrest of the disease in the later stages affords a more striking lesson, and in other ways is of greater educational value.

Value of rest.

Whenever there is active inflammation in the lungs bodily rest is imperative. This is common-sense and

merely an adaptation of Hilton's classical essay on rest and pain. Hilton showed conclusively that in the acute stages of inflammation, whether it be of an extremity or of an organ, movement does nothing but harm. No one thinks of permitting exercise in the case of typhoid fever or of pneumonia, and the same should be equally true of the inflammatory stage of tuberculosis. This view is accepted in the case of tuberculosis of the hip-joint, and should be adopted when the lungs are the seat of disease. In the case of pulmonary tuberculosis we know that as soon as inflammation commences Nature takes prompt steps to diminish the movement on the side affected. Bonnet Léon and Walsham have shown by means of the X rays that under ordinary conditions the diaphragm does not become flatter on inspiration, as was supposed, but that it plunges up and down like a piston without any alteration in its curve. Whenever one of the lungs is affected, however, with tuberculosis, even if the disease is limited to the apex, the movement of the diaphragm is sensibly diminished on the affected side. Again, every pathologist knows that when the lungs become tuberculous adhesions are formed, in the majority of cases, between the lungs and the pleura. Nature, by means of these anchors and by diminishing the movement of the various muscles of respiration on the affected side, makes every endeavour to keep the diseased part at rest.

Nature is usually a safe guide, and experience has shown that in all stages of tuberculosis one of our chief efforts must be to prevent anything which tends to throw a strain upon the lungs, such as dyspnœa or cough. One of our aims in sanatorium treatment is to maintain the temperature of our patients at a normal level. Now, exercise is one of the chief causes of a rise of temperature in this disease, and has, in fact, been used for diagnostic purposes. In the acuter stages of the disease pulmonary rest can only be insured by absolute bodily rest. In this way we allow the diseased part of the lungs time to heal by natural processes, and the record of such treatment shows what excellent results may be obtained ; the inflammatory process gradually diminishes and the disease becomes quiescent.

Disadvantages of too prolonged rest.

Just as in the case of a fractured leg there comes a time when massage and passive movements are imperative, so when tuberculous disease has become sufficiently quiescent exercise in some form or another must be taken. It is admitted by all physiologists that for the body to be in perfect health it must be maintained in activity. Exercise promotes not only the nutrition and energy of the voluntary muscles, but also those of the heart, blood-vessels, and respiratory organs. It powerfully assists the aeration of the blood, and in this way keeps all the tissues of the body in a healthy condition. An

equally important function of exercise is that it assists in the elimination of various substances through the lungs, the kidneys, the bowels, and the skin. Another advantage, as Sir H. Weber has said, is that it strengthens the nervous system and counteracts the mental depression which has such a lowering effect on the vitality of the body. On the other hand, it has been urged, and justly urged, that patients who undergo treatment by rest in the recumbent posture become lazy in the extreme, and never regain energy enough to resume their former mode of life. This is an important point in the case of patients who are not possessed of ample means, for we must endeavour, by every means in our power, to arrest the disease under conditions which are, as nearly as possible, those obtaining in the life to which our patients have to return. Meissen, who values the Liegehalle method, asserts that he has never seen a patient attain the maximum development of health by this measure alone. He has, he says, seen better results in those patients who have taken more exercise than they ought to have done. Brehmer was convinced that the reason why Dettweiler at one time obtained unfavourable results, and thus was led to alter his treatment, was that the patients at Falkenstein were allowed to walk too fast, and that the return walk was often uphill. Dettweiler himself has freely confessed that the

method of treatment which he introduced may be carried to an extreme; for when the patient is kept at rest for long periods in the quiescent stage of the disease, there is a rapid gain of weight, which consists largely of fat rather than muscle or bone, and a time comes when the capacity of the lungs and heart is overstepped and the patient becomes more breathless than before. Sir R. Douglas Powell has observed that such a transgression of the physiological balance of the cardio-respiratory functions and body-weight is to the positive disadvantage of the patient, and results in an attack of dyspepsia, diarrhœa, or hæmoptysis, by which Nature attempts to rectify the effects of our want of foresight. Patients with extensive disease are, indeed, more comfortable if their weight does not exceed a certain limit. Knopf, too, who was at one time Dettweiler's assistant, asserts that the recumbent position necessitated by Liegehalle, facilitates hypostatic congestion of the lungs, and that the patients' backs become more sensitive to changes of temperature. The relative statistics of 'cures' which have followed on the adoption of these two forms of treatment cannot be accepted as a guide for many sufficiently obvious reasons, but remarkably good results are obtained at such places as the Nordrach Colonie, where exercise is prescribed at the earliest possible moment. We may confidently

assert, from our own observations of many cases treated by both methods, that the Liegehalle system does not lead to such good or to such permanent results as the system adopted by Brehmer and Otto Walther. It must be remembered that cases in all stages of the disease are admitted at Nordrach, and that the good results there, are obtained not only in the early stages of the disease, but also in the more advanced ones. If exercise benefits patients with extensive disease, it cannot fail to be of service to those whose disease is less advanced. Finally, at several sanatoria, as, for example, Dr. Driver's at Reiboldsgrün, better results have been obtained, since patients were permitted to rest in shelters and in the woods rather than in Liegehalle. We see, then, that there is much to be said for exercise, and but little for complete rest, in certain phases of the disease. We may also conclude that the form of exercise adopted must be of such a kind that, whilst it leads to active and healthy metabolism, it does not throw any strain upon the lungs or excite dyspnœa.

Where should the patient rest?

It is clear, however, that rest must frequently be enforced by the physician—for example, when there is active inflammation, and, as we shall see, for an hour before the mid-day and evening meals, even when the patient is convalescent. How can this rest be most efficiently secured? Is it most easily

obtained in Liegehalle or in the seclusion of the patients' own rooms?

Objections to verandas.

In the first place, in many cases in which rest is necessary, the effort involved in going from the bedroom to the veranda, and of leaving it for meals, or for certain physiological processes, entails too much exertion. Again, in verandas patients tend to collect in chattering groups, and, forgetful of advice, gesticulate and become excited, so that dyspnœa or cough is induced; whilst many who need absolute quiet make efforts to entertain their neighbours. If intervening glass screens are placed to prevent this, one of the main advantages of a veranda is lost. In addition, there are many structural objections to Liegehalle; in the climate of England they block out too much light, unless the building is so arranged that they are placed before a basement or the interval between the stories is much increased, both of which procedures lead to a large outlay without any compensating advantage. Verandas are not easily kept clean, in the strict sense of the term, and in the nature of things cannot contain as pure an atmosphere as is found in the open, or even at the window of a room that contains only one person; further, they interfere with the privacy of patients confined to bed and may disturb their rest, whilst in summer they sometimes tend to become insufferably hot.

Brehmer and others, recognising the enormous

Absolute rest possible only in seclusion

part that the mind plays in the question of bodily health, insisted that when rest was required it should be absolute ; that both mind and body should be free from all forms of excitement. They held that this can only, as Leriche has proved, be done by means of complete seclusion, and the results obtained by them have more than justified their assertion. They have, however, found that in a small number of instances the patients tend to become depressed, and fail to make progress, when isolated in this manner, and they have come to the conclusion that patients of this class when kept at rest do best if they are allowed to associate with not more than two or three fellow-creatures for an hour or two daily, preferably in open-air galleries to which their beds may be wheeled. We see, then, that most patients, when their condition necessitates rest, should be confined to their own rooms. Most medical men object to a patient remaining for long in a single room, but, as we shall show, such a room may be most freely ventilated, and this argument therefore loses its force. Further, in a sanatorium there should be some form of open-air gallery, provided that not more than three, or at most four, persons are allowed to assemble together.

A more difficult question, which we now have to answer, is, Under what conditions should exercise

When should exercise be prescribed?

be prescribed? Nowhere in the extensive literature on the subject are these conditions laid down, whilst the answers given to this question by the medical men in charge of a number of sanatoria, which are brought together in Appendix No. V., p. 158, show that no absolute rules can be given. The reason for this is that the conditions under which exercise should be prescribed depend largely on the personal equation of the patient, and on the individual merits of each case, which can only be dealt with, and properly appreciated when the physician is in close attendance upon the patient. This, indeed, is one of the most valuable lessons which the sanatorium method of treatment has taught us. There can be no rule. It may, however, be said that exercise may be prescribed whenever it does not tend to exacerbate the disease, and that this can only be determined in each individual case by experiment, guided by the observation and experience of the physician. It is true that a patient should be kept in bed until he can take ordinary food, and that certain conditions, such as the height of his temperature, the rapidity of the heart's action, a ready tendency to exhaustion, extensive or rapidly-advancing disease, or an irritable nervous system, may contra-indicate exercise and necessitate repose. A temperature of 98·6° F. in the morning may indicate the desirability of rest in certain cases, but we have known patients

with a temperature of 100° F. or more fail to make any progress until they were permitted to take a certain amount of exercise.

What form of exercise is advisable?

When exercise is prescribed, what is the best form? More people suffering from tuberculosis have been killed by over-exertion than by anything else. Exercise must therefore never be pushed so far as to cause fatigue, or to lead to a return of fever or cough or to any other bad symptom. For some patients slight massage or the mere exertion of dressing may be enough; others may only be able to walk a few yards on level ground. Others again of the well-to-do class may benefit by driving slowly in ordinary carriages or in suitable electric motor-cars, but for the majority of quiescent cases experience shows us that the best form of exercise is regular uphill climbing. Such exercises must be gradual and deliberate; the gradient must be easy, and the pace should not, in many cases, exceed two miles an hour. The patients must not hurry, even if caught in a shower, for any increase in the number of respirations does harm, in that it increases the work of the lungs. Every provision must be made for the patients to rest if they are at all tired; whilst the sanatorium must be so situated that patients are not tempted to start downhill and return uphill. Both the public and the medical profession are too much afraid of a little rain or

mud, and one objection urged against this form of exercise is that it may lead to exposure to heavy rain or inclement weather. The experience of the sanatoria where this form of treatment is practised, on the other hand, shows that it leads to very good results.

What protection should be afforded?

The only precaution taken in these institutions is shelter from wind; it is argued that no rheumatism and no chill result even from a thorough wetting, and some authorities go so far as to prefer their patients not to change their clothes even when wet through. The general consensus of opinion, however, is that, even if wet clothes do not lower the vitality, they can at least do no good. Again, it is uncomfortable to remain long in wet clothes, so that adequate provision should be made in a sanatorium for drying the patients' garments. Protection may be obtained by means of trees or suitable shelters in the grounds, and the paths should be so constructed that they absorb moisture and readily dry after rain. Exercise under cover, as Brehmer has shown, cannot, save in exceptional instances, be of service, as it is impossible to keep the atmosphere sufficiently pure where any number of people are assembled together. No provision, then, need be made for exercise under cover, although there can be no objection to suitable covered passages which are freely open at the sides being erected between

certain of the different buildings, more especially as these conduce to the comfort of the patients by sparing them unnecessary exposure to rain.

Are other forms of exercise advisable?

Slow walking uphill, on easy gradients, as we have seen, is the best form of exercise for persons suffering from pulmonary tuberculosis; but, in view of the fact that at many sanatoria certain exercises, such as billiards, tennis and golf are allowed, we must say a few more words on this subject. As Sydenham long ago pointed out, horse exercise is often of service to tuberculous individuals, and provision may be made in this direction for the higher class of patient. Games like billiards, tennis, golf, and others which involve much exertion and tend to excitement, are injurious unless the disease is practically arrested, in that they cause dyspnœa, raise the temperature, and lead to an exacerbation of the pathological process. Brehmer recalls cases in which he considered that hæmoptysis was directly brought on by a game of billiards, either from patients stretching over the table or holding their breath when making a difficult stroke. It is true that some persons afflicted with tuberculosis may indulge in pastimes of this kind without apparent harm, but such patients are sufficiently improved to be able to leave the sanatorium, whilst, if they remain, they must inevitably postpone the admission of more suitable cases. That the avoidance of any over-

exertion is of great importance is shown in Manders Smythe's account of his own case, in which he relates how, after months of improvement, he suffered a relapse, owing to a comparatively trivial amount of tobogganing—a relapse which cost him five months of extra treatment. Such an example of harm resulting from the imprudence of patients is far from uncommon.

Another form of exercise which is not infrequently practised at sanatoria is pulmonary gymnastics, by means of the pneumatic cabinet and other contrivances, the idea being that the healthy portion of the lung is hypertrophied, and so the loss of tissue compensated. Brehmer, Liebermeister and Volland were strenuous opponents of this form of exercise; Baümle asserts that it has set up aspiration pneumonia; Michaelis and others have recorded instances of harm resulting from its use; whilst at the Volksheilstätte, Loslau, it has been tried and given up. Many authorities, on the other hand, show good results from this form of treatment in cases in which the disease was practically arrested. Such exercises may readily throw a strain on the lung in cases where tuberculosis is not permanently arrested, and may thus set the smouldering disease aflame; the limits of compensation are readily overstepped, with the result that a harmful emphysema may be developed. On the other hand, it is questionable

whether such expansion of the lungs is necessary, for, as C. Theodore Williams has pointed out, the human body has a much larger lung surface than is required for ordinary respiration. Under ordinary circumstances an individual does not expand his lungs more than one-half, whilst a patient may exist in bed with an expansion of one-twelfth. Loss of lung tissue does not necessarily mean that the respiratory capacity is below the ordinary needs of the patient. There is ample lung surface in most consumptive individuals to deal with the amount of blood in the body, and there is no necessity for them to inflate their chests unduly, and thus run the risk of strain, the development of emphysema, and with the latter the tendency towards hæmorrhage.

Conclusions. We may conclude that—

1. Arrangements must be made for four classes of patients :
   - (*a*) Those who can take exercise more or less freely.
   - (*b*) Those who can only take slight exercise on level ground.
   - (*c*) Those who should be isolated in their own rooms.
   - (*d*) Those who, though unable to take exercise, should be allowed to associate with a few other patients in a small open-air gallery or other form of shelter.

It must be borne in mind that those cases which are included under (*a*) and (*b*) not infrequently relapse, and so come under either (*c*) or (*d*).

2. A few open-air galleries are of service, but nothing approaching the Liegehalle system should be erected.
3. Numerous paths should be provided, some on level ground, and others of various gradients for uphill exercise. All must be of such a character that they readily dry after rain.
4. No special arrangement need be made for exercise in bad weather under cover, though it is as well to provide covered passages between certain of the different buildings.
5. Adequate accommodation must be afforded for drying clothes.
6. Exercises, such as billiards, tennis, golf, and pulmonary gymnastics, which tend to cause dyspnœa or undue expansion of the lungs should not be allowed in a sanatorium, unless it is reserved for essentially quiescent cases.
7. Some of the more wealthy patients may be allowed horse exercise, whilst many patients derive benefit from suitable carriage exercise.

4. An Abundant and Varied Dietary in which Milk, Butter, Fat, and Vegetables occupy an Important Place.

ature of tchen re- irements.

A marked feature of tuberculosis is the loss of appetite which results from the progress of the disease, and it is consequently agreed upon all hands that in the treatment of this disease one of the most important points is to insure that sufficient nourishment is taken to make up for past loss and to maintain the body-weight appreciably above its normal value. In this way the process of repair is stimulated, the resistance of the individual increased, and the susceptibility or tendency towards relapse lessened. So true is this, that Sir R. Douglas Powell considers the sanatorium cook to be only second in importance to the physician, whilst Dettweiler, when asked whether he used drugs much in the treatment of consumption, pointed to his kitchen, and exclaimed, 'That is my pharmacy; there is my chemist's shop.' The object of the dietary is to increase the weight gradually to the normal, or somewhat above the normal, value, for, as Weir Mitchell has shown, a gain in weight up to a certain point goes hand-in-hand with a gain in all other essentials of health. By weighing the patients once a week a good guide up to a certain point is obtained of their progress, and at the same time a healthy and friendly rivalry

is established between individuals. The quantity of food eaten must be considerable, must at least equal in amount that which is eaten by an ordinarily healthy individual, whilst patients must be made to eat everything they are given under pain of being sent away, as this disciplinary measure is productive of most excellent results. Although it is found that solid food is infinitely the best, and that in many cases it affords the readiest means of reducing fever, yet in a sanatorium, owing to the different stages of disease which are treated, the diet must range from the fever diet of a hospital to a full diet of plain and wholesome food. Consequently, the kitchen arrangements must be such that they can meet these demands. Further, as is now well known, food is liable to become poisonous when stored in unwholesome surroundings, and it is therefore necessary that the kitchen, larder, and other offices should be dry, well ventilated, and free from any source of contamination.

Facilities necessary for the analysis of certain articles of food.

With regard to the character of the food, we may say at once that tuberculous patients do best on an ordinary diet to which an excess of fatty material is added. Otto Walther lays great stress on the amount of butter which his cook gets into the gravy in as pleasant and unobtrusive a guise as possible, and on the amount of starch in the potatoes. Walther, in fact, has the potatoes and other articles

of food carefully analyzed before use, so that a thoroughly equipped sanatorium should have facilities for analysis of this kind. Brehmer insisted on the importance of an ample supply of vegetables, as he said that without them patients with advanced disease chew the meat, roll it from side to side, and are unable to swallow it. Vegetables, on the other hand, need little chewing, but are easily swallowed, and help the deglutition of other food. Further, vegetables contain much of the carbohydrate material recommended by Strumpell and Eichhorst. A sanatorium should therefore have a well-stocked kitchen-garden. Fruit is a most useful adjunct, and a room should be set apart for its storage.

Are arrangements for securing milk free from tubercle bacilli necessary?

Milk is one of the best foods for increasing the weight, and the question arises whether, in view of the large number of tuberculous cows in existence, precautions should be taken to sterilize it, or whether it should be obtained only from animals which have passed the tuberculin test. Koch has shown that human tubercle bacilli have not, as a rule, sufficient virulence to infect cattle, and he has argued that there is no evidence to show that human beings are affected by bovine tuberculosis. It has, however, been shown that the two varieties of bacilli have the same morphological, cultural, and tinctorial characteristics, and that cattle suffering from tuberculosis give a reaction to tuberculin made from human tubercle

bacilli. Dinwiddie, Ravenel, and others, have further proved that, of the various forms of animal tuberculosis, bovine tuberculosis is the most virulent. These authors have been able to infect every kind of domesticated animal with bovine tuberculosis, and it would be indeed strange if human beings were unique amongst animals kept under domesticated conditions, as being immune to bovine tuberculosis. That they are not thus immune was conclusively shown at the late Congress in London, by the fact that veterinary surgeons have been inoculated on their fingers with bovine tuberculosis, and have subsequently developed the disease. Whether such infection is at all frequent is still *sub judice*, but until the Royal Commissions now sitting in England and in Germany prove the contrary, we are justified in saying that milk taken by the patients should be sterile, more especially in view of the fact that patients with tuberculosis are probably more liable to further infection, possibly with a more virulent type of the bacillus, than ordinary individuals. Milk should be sterile. English people, according to Sir R. Thorne Thorne, are the only civilized people who habitually consume uncooked milk, owing to their rooted objection to boiled or scalded milk. Consequently, the milk used should be obtained from healthy cows but should not be boiled. Great care must be exercised in the feeding of the cows, every

arrangement being made in the cowshed and the dairy for keeping the animals healthy and the milk free from contamination. Butter is used in this form of treatment in very large quantities, and should be above reproach. Meat may occasionally be the cause of infection, but any danger from this source is readily avoided by sufficient cooking.

Conclusions.

We may conclude that—

1. The equipment and the sanitary arrangements of the kitchen, larder, etc., must be of the most modern type.
2. Every precaution must be taken in the dairy of the farm to insure a large supply of milk and butter which is pure and free from tubercle bacilli.

5. Various Hydro-therapeutic Measures.

Necessity for an adequate provision of baths.

One of the most noticeable features in tuberculosis when at all advanced is the unhealthy character of the skin. Perspiration is readily produced, whilst parasitic skin affections, such as pityriasis versicolor, are frequently met with. It has been found that the best way of improving the action of the skin, and at the same time diminishing the liability to what is termed a chill, is by appropriate hydro-therapeutic measures, more especially by means of some form of needle or shower bath, combined with friction, provided always that the

individuals are not allowed, by vigorous drying or in any other way, to tire or over-exert themselves. In some of the Continental sanatoria a great parade is made of the bathing portion of the establishment, but in England, where the daily use of a cold or tepid bath is so much more common, there is no necessity in erecting a sanatorium to do more than furnish an adequate supply of the necessary bathrooms.

6. Facilities for Observation and Research.

Special accommodation for dental and throat operations, the use of X rays, and the like, which are necessary adjuncts to a sanatorium, together with laboratories for routine examinations, should be provided. In addition, enough has been said to show the many opportunities that exist in a sanatorium for the prosecution of research. Such questions as the possibility of re-infection, the varying virulence of tubercle bacilli, and the diagnosis by means of serum agglutination, must be elucidated by the help of appropriate bacteriological and pathological laboratories. Many problems, such as those considered by Bardswell, as to the effect of different kinds of food and the various metabolic changes which occur in tuberculosis, must be considered in a chemical and physiological laboratory. Of late years it has been the fashion to neglect atmospheric

changes completely, but it is nevertheless a fact that certain climatic conditions exert different effects on individual patients. One patient may benefit by a relatively high humidity, another may require a drier atmosphere, and, in our opinion, the varying effects of atmospheric conditions upon the well-being of the patients should be carefully worked out by the establishment of a meteorological observatory, such as has long existed at Görbersdorf. Finally, every facility should be provided, in the shape of a record-room, for keeping full notes of the patients' progress.

7. Constant Medical Supervision.

Need of supervision.

We have seen in the previous pages that sanatorium treatment is based upon a careful regulation of a patient's life in all its hygienic and medical details, and it is to the attention to detail, and to the avoidance of what is harmful, that this form of treatment for tuberculosis owes its extraordinary results, and its superiority over all other forms of treatment. Solly has shown by statistics that in the beautiful climate of Colorado there is an enormous difference in the mortality among consumptive patients under medical control compared with that of those who merely consult a physician when they think it necessary. In order to direct a sanatorium efficiently, the physician must have absolute power;

he must be an autocrat, and his word must be law. He must be prepared to give his entire energy to the work, for, as Dettweiler has expressed it, a sanatorium must be his religion, his politics, his despair, and his delight. He must be a man of many parts; he must gain the confidence of, and if possible make allies of, the patients, prevent imprudence in some cases, encourage perseverance in others, strictly enforce all essential rules, and yet allow sufficient liberty in less important details to prevent the irksomeness of restraint. Tuberculous individuals have a happy-go-lucky way of following their own devices, and are in constant need of supervision. One of the many lessons sanatorium treatment has taught us is that every detail likely to exercise an influence upon either the condition of the general health or upon the course of the disease must exercise the physician's most earnest attention. Even in health people differ greatly in their power of reaction, so that what is bracing to one is depressing to another. 'What is one man's meat is another man's poison' is an old saying, but never more true than of tuberculosis. In this disease we have an ever-changing picture. In its treatment there is no fixed rule, and such general rules as exist have to be altered more frequently than they are followed. Each tuberculous individual must be dealt with on his merits; his personal equation and his power of

reaction must receive the most painstaking consideration. It is only by constant medical supervision that we can take advantage of the variations in his condition or prevent harm. The physician should visit each patient before breakfast, and again twice a day—for example, after the morning and afternoon walk—so that he may see at once whether any exhaustion or other bad effect has supervened. In this way he is able to map out the daily details of the individual patient according to his condition. Those who are kept at rest may occasionally require even more frequent visits. Again, the physician must take his meals with the patients. In this way he can apportion the amount of food according to the varying requirements. He can sit near and encourage those who have any difficulty in eating the rather large quantities of food which are necessarily given them, and he can do much to prevent by his presence the many petty deceptions, such as the pocketing of food, of which experience has taught us sanatorium patients may be guilty. The grounds must be as far as possible overlooked by the physician, so that he may be able to observe the patients' doings, and see that they carry out his instructions. He can in this way often discover that the reason why a patient does not improve is because he walks too fast when he thinks he is out of sight, or commits some other folly. Ex-

perience has shown that when patients believe themselves to be within the physician's sight they are more careful to observe the necessary regulations.

Conclusions.

We may conclude that—

1. The buildings of a sanatorium should not extend over so large an area that effective medical supervision is in any way interfered with.
2. The quarters of the medical staff should, as far as possible, overlook the grounds.
3. The medical staff does not require a separate dining-room.

The Main Principle of Sanatorium Treatment.

Modern aspect of Brehmer's essentials.

The main principle then, running through the sanatorium treatment is to treat tuberculous disease on common-sense lines—in other words, to develop by every possible means the resistance of the body, so as to render the tubercle bacilli innocuous. Brehmer's essentials may now be modified as follows:

1. A continuous supply of pure fresh air with no unnatural variations of temperature.
2. The avoidance of re-infection and of all sources of irritation, such as dust.
3. Good nourishing food in sufficient quantity to establish and to maintain the normal body-weight of the patient.

4. Constant supervision by a skilled physician, who so orders the patient's life that he avoids everything which is harmful, and takes advantage of everything which helps the process of repair or develops the powers of resistance.

We will now briefly state the necessary daily routine of a patient who is allowed to take active exertion, in order that the general lines of the form of treatment we advise may be clearly grasped.

Daily Routine.

To take the case of a convalescent patient in the colder months. The patient is called at 7 in the morning, and the windows of his room are then closed, in order that he may not be chilled whilst dressing. He takes his temperature, rises not later than 7.30, and then has a shower-bath at a temperature, in most cases, agreeable to himself. On completion of his dressing he must open the windows. Breakfast is at 8 o'clock. Directly after breakfast, or at 8.30, the patient starts out on his morning walk, the length of which is graduated according to his condition. He walks deliberately and slowly until he has arrived at his destination, and waits there, resting in the fresh air, but protected from the wind, until it is time for him to start home again. At 11.45 he must be in

his room, where the windows have been already shut, and take his temperature. In five or ten minutes he must open the windows. Between 12 and 1 o'clock he lies resting at full length on a sofa-chair. At 1 o'clock he leaves his room and has luncheon, the principal meal of the day, with his fellow-patients. Not later than 2.45 the patient starts on his slow afternoon walk, which is the shorter walk of the day. He rests as before when he arrives at his destination, and slowly returns, so that he reaches home at 5.30, or, if it is very cold, at about 4.45. He again takes his temperature, opens the windows, which have been closed shortly before his return, and rests until dinner-time. At 7 o'clock he joins the other patients at dinner. After dinner many of the convalescent patients may spend half an hour to an hour in the recreation-room. They retire to their own rooms by 9 o'clock, open their windows, take their temperature, and should be in bed by 9.30 or 10 o'clock. As may readily be seen from the preceding pages, the above routine may have to be frequently altered to suit the varying requirements of the different phases of the disease. Each patient, as we have said, is visited at least three times a day by the physician ; he is weighed once a week, whilst every fortnight his chest is thoroughly examined and every month his sputum is tested.

Tabulation of Requirements for a Sanatorium.

We are now in a position to tabulate the requirements for a sanatorium at which the treatment of tuberculous disease may be carried out efficiently, apart from the question of personnel, with which we shall presently deal. It is agreed that the accommodation for all patients must be comfortable, a separate room being provided for each; that the sanatorium should be on an elevated and sloping site, with a sunny exposure and well sheltered from cold winds; that it should have a farm at a convenient distance, be surrounded by extensive grounds, well wooded, and affording ample space for exercises of various kinds; that the soil should be dry and permeable and the water-supply abundant; and that it must be fitted with the latest sanitary arrangements and equipped with all requirements for scientific research. In addition, we have shown in the preceding pages that—

1. The ventilation should be such that the air contained within the rooms and passages is free from all sources of contamination, and rivals the outside air in point of purity, whilst at the same time draughts are not encouraged.
2. The buildings should be so situated and of such a kind that dust is as far as possible avoided.

3. The buildings and the fittings should be of such a kind that the dust which inevitably collects can be readily removed.
4. Arrangements should be made for the ready and effectual destruction or disinfection of all infected material.
5. The buildings should be of such a nature that constant medical supervision can be readily exercised.
6. The quarters of the medical men should, as far as possible, overlook the grounds.
7. The bedrooms of the sexes should, as far as possible, be in different blocks, but there is no necessity for separating the men and women in the dining-room or grounds.
8. Four classes of patients must be provided for both in the sanatorium and in the grounds:
    - (*a*) Those who can take exercise more or less freely.
    - (*b*) Those who can only take slight exercise on level ground.
    - (*c*) Those who must be isolated in their own rooms.
    - (*d*) Those who, though unable to take exercise, may be allowed to associate with a few other patients.

9. The accommodation for visitors must be limited.
10. No provision, so far as the buildings are concerned, need be made for amusements beyond an entertainment-room which may also serve the purposes of a library.
11. No provision should be made for games, such as billiards, golf, and tennis, which involve much movement of the arms or lead to excitement.
12. A few open-air galleries are of service, but nothing approching the Liegehalle system should be erected.
13. The dining-room and kitchen should be completely cut off from the patients' rooms, but no separate dining-room need be provided for the medical staff.
14. The kitchen arrangements should be of the most modern type and thoroughly sanitary.
15. The dairy and the farm should be of a model character.
16. There should be ample accommodation for hydro-therapeutic measures.
17. Adequate arrangements should be made for drying clothes.
18. The heating arrangements should be such that the temperature is never raised more than a few degrees above the outside

temperature, so that no sudden variations are experienced when the patient leaves his room, and that the humidity of the air is not sensibly diminished.

19. Adequate shelter should be provided in the grounds and elsewhere against wind, excessive sun, or heavy rain.

20. No special arrangements need be made for exercise under cover in bad weather, though it is as well to provide covered ways between certain of the different buildings.

21. All facilities should be provided for the treatment and clinical observation of the patients by the aid of laboratories and special departments.

22. The facilities which should be provided for research include more especially facilities for observations in bacteriology and pathology, chemistry, physiology, and meteorology.

PART II

AN ATTEMPT TO CARRY OUT THE FOREGOING PRINCIPLES BY THE CONSTRUCTION OF SUITABLE BUILDINGS.

We must now make an attempt to meet the various requirements we have formulated by the erection of suitable buildings, but before doing so we must arrive at some decision as to the special forms of tuberculous disease which are likely to derive benefit from treatment in a sanatorium. Children usually interfere with the necessary discipline, and require special arrangements for their education; further, they make greater and more rapid progress, according to our experience, when treated in an establishment specially set apart for them. We do not, therefore, propose to find any accommodation for children. We think it right to find accommodation for those patients who are suffering from pulmonary tuberculosis, and from one cause and another have to be confined to bed for weeks, or possibly months. Although these patients may remain a considerable

time in the sanatorium, yet the improvement in their condition tends to arrest the attention of the public more than the results obtained in less advanced cases, and in this way the severer cases may prove of distinct service in educating the public mind as to the value of the treatment. The class of case suffering from tuberculosis which is refused at various sanatoria is shown in Appendix No. IV., p. 157. Those surgical cases which require rest, such as cases of hip-joint disease, may be treated as satisfactorily, if not more so, at a seaside resort as at a sanatorium. Other forms of the disease, such as lupus, tuberculous glands, tuberculous laryngitis, and disease of bone in the arm, may derive great benefit from sanatorium treatment, but these necessitate no special structural arrangements beyond the provision of an operating theatre and examining rooms.

We may now turn to the

Question of the General Character of the Buildings.

Whether the sanatorium should consist of one large block or several smaller ones.

Existing sanatoria, as may be seen from Appendix No. VII., p. 164, fall under two groups —namely, those sanatoria which consist of one large building and those which consist of several. Both systems have their advocates. Their respec-

tive advantages and disadvantages may be tabulated as follows :

One Large Building.

Advantages :

(*a*) Less costly to erect and maintain.

(*b*) More readily and more cheaply supervised.

(*c*) Sanitary arrangements simpler.

(*d*) Readier access of patients to common rooms.

(*e*) Lifts more readily provided.

Disadvantages :

(*a*) Much noiser than smaller buildings ; for example, the sound of coughing (by advanced cases confined to their rooms) may be heard in the dining-room and prevent sensitive patients from eating.

(*b*) Impossible to ventilate or to vary the ventilation and temperature for special cases so satisfactorily as in smaller buildings, more especially when there are several floors. The smell of cooking may, for example, penetrate the bedrooms of the patients, or rooms on one floor may ventilate into those above.

(*c*) Much greater difficulty than in smaller buildings in classifying the patients according to their condition, and thus avoiding the moral effect which severe

cases have on those who are comparatively well.

(*d*) Greater difficulty in isolating any cases of infectious disease.

(*e*) Not so readily extended ; for example, additional small buildings are subscribed for more readily than the extension of a single large building.

A subsidiary point is that the smaller roof area of one large building collects a smaller amount of rain-water for laundry purposes.

From a strictly medical point of view, there can be no doubt that numerous small buildings within such limits that supervision is practicable are the best. Many of the older sanatoria which are on the one-block system were adapted from ordinary houses ; others of the one-block system are now being extended by means of smaller villas ; whilst in most of the more recent sanatoria for a large number of paying patients, the separate-house system is adopted in some form or another. Naturally, national prejudices have to be taken into account, and what may be suitable for snowy Switzerland or sunny Colorado may not be suitable for England. We prefer the separate-block system. It is impossible, however, to give a definite opinion on this matter without knowing the character of the

site and the local configuration of the ground; for example, the separate-block system necessitates that the proposed site should have sufficient shelter and protection for all the buildings. Then, again, the question of expense must enter largely into the decision. Consequently, although our plans have been drawn up from the point of view that the system of several separate houses is the best, we have added an alternative plan, which embraces the same principles on the one-block system, in case either the site or financial considerations should necessitate its adoption.

The Necessary Buildings.

We must have an administration block, in which the dining and kitchen accommodation for the majority of patients is placed, and an engine-house, together with laundry and other accommodation. We consider, further, that the twelve well-to-do patients should have a block to themselves. With regard to the eighty-eight more necessitous patients, we are of the opinion that a separate villa should be provided for those patients who, from the fact that they are confined to their rooms, require more quiet. A villa of this kind is being provided at Linford and other sanatoria. The more serious cases should be housed here, whilst it is often a good plan to take new patients into what we may term the

hospital block, and then, after the individual peculiarities of each case have been thoroughly grasped by

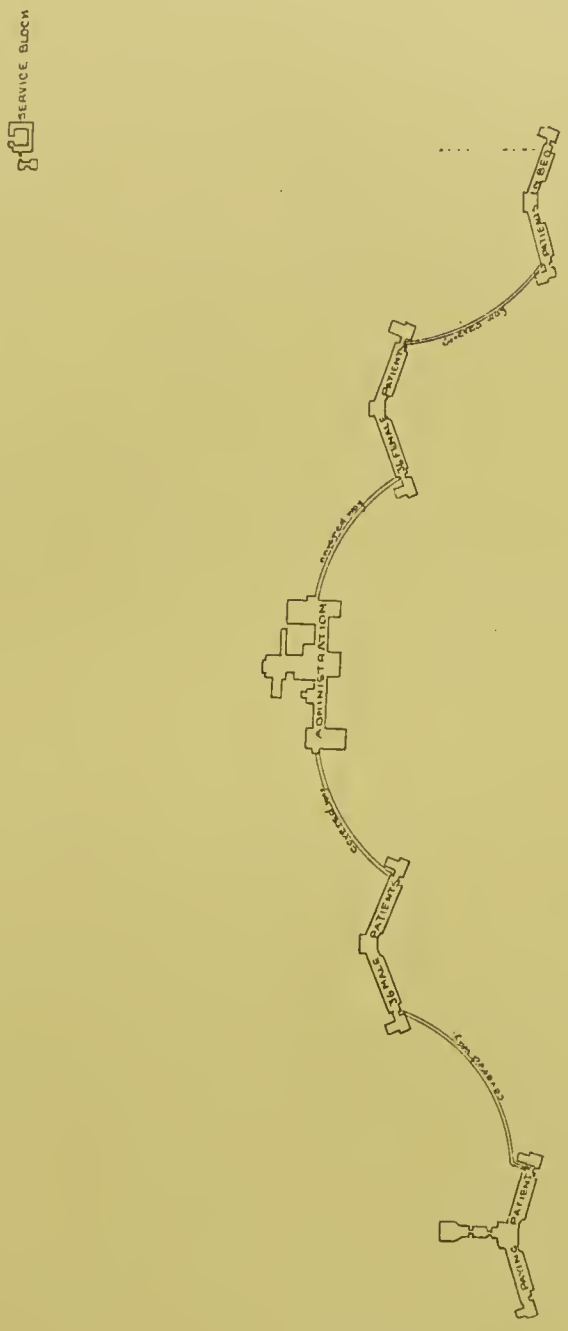


FIG. 1.—BLOCK PLAN OF BUILDINGS.

sufficient observation, and the patients are sufficiently well, to draft them on to other houses. The men

and women who are not confined to a sick-house like this should, as we have pointed out, be placed in separate blocks. The number of the patients in each house of this kind depends both on the nature of the cases treated and on the amount of money to be expended on the building and the service. We would suggest, however, that the hospital block should find accommodation for sixteen patients. At the Nordrach Colonie, where all stages of the disease are treated, and where there are now some seventy beds, from ten to twelve patients are usually confined to their rooms; and at Nordrach no particular provision is made for surgical cases. We would also suggest that one block should provide accommodation for thirty-six men, and another for thirty-six women.

The Aspect and Position of the Various Buildings.

Aspect.

It is shown by Appendix No. X., p. 173, and especially by the results obtained at the Nordrach Colonie, that the mere aspect of a patient's bedroom has no marked effect on the results of treatment at an efficient sanatorium. There can, however, be little doubt that, for patients who are confined to their own rooms, as many must be from time to time, it is advisable, from the point of view of their comfort, that the buildings should be so placed that

they take advantage of the rays of the sun, which are grateful to the patients and are Nature's best disinfectant. Again, the aspect must be such that the bedrooms are as much sheltered from strong winds as the nature of the site allows. It is, however, a mistake to place a building in such a sheltered position that no movement of air occurs, for it is on the free circulation of the air that we must rely for the purity of our atmosphere. In order to obtain abundant light, the main front of the building should be south, south-south-east or south-south-west. A directly south aspect is not so good in summer, as the rays of the sun stream more directly into the patients' bedrooms and are apt to cause these to become unpleasantly hot. These effects can be avoided by removing the patients to northern bay-windows, or to open-air galleries, such as we have provided; but Demany and Jorvisenne have shown that in a climate such as England's the best aspect for the main front of the buildings is south-south-west or south-south-east, provided that there is no very high hill in the neighbourhood to cut off the light. With both a south-south-east and a south-south-west aspect the sun will shine mainly on the roof in summer, and into the patients' bedrooms in winter. Another consideration, in connection with this question, is the direction of the prevailing winds. This must depend largely on the character of any particular

site, but as a rule, in England, it is most serviceable in the treatment of tuberculosis to have protection against the northerly and easterly winds; consequently we have designed the individual blocks in such a way that they consist of a central portion with two wings drawn at an angle of 145°. The central portion (see Fig. 10, p. 129) contains an open-air gallery and looks directly south; one wing faces south-south-west, the other south-south-east. In this way advantage is taken of the sunshine on the northern as well as on the southern aspect, whilst the two wings and their sanitary towers tend to shelter each other from the effect of the wind. The aspect of the bedrooms in seventy-two sanatoria is given in Appendix No. XI., p. 174. It is at once clear, from what has already been said, that the engine-house should be well removed from the sanatorium proper, both on account of the noise it creates and of the possibility of dust.

Position.

The separate blocks must be as far as possible removed from all other sources of noise, and must, further, be so placed that the ground in front of the main aspect can be well cleared from trees and shrubs, so that a free circulation of air is permitted and the patients are able to enjoy the view. Again, in the immediate vicinity there must be a sufficient number of trees to afford adequate shelter to those patients who are restricted

to a small amount of exercise. The administration block must not be placed in such a position that any fatigue is experienced by even feeble patients on their way to it from their own rooms; it should be placed at a *slightly* higher level than the others, so that no smell of cooking, dust, and the like, is carried from it to the smaller buildings. This position also serves the purpose of not interfering with the view of the patients, or with the free circulation of air in front of the individual rooms. The exact position of the various buildings must depend on the individual site, but care must be taken that they are placed in such a position that patients never have to descend from the sanatorium buildings to ground at a lower level. A general view of the aspect and position of the buildings proposed may be seen from Fig. 1, p. 73.

General Details of Construction.

General considerations.

Our aim is to construct a building which shall meet the requirements laid down, but we must at the same time strive to make the ensemble as attractive and cheerful as possible, and avoid the dreariness inseparable from a hospital. The main considerations which, as we have seen, should guide us in the construction of our buildings are that every part must be well ventilated and capable of being easily flushed with a continuous supply

of fresh air, readily cleaned, and freely open to the sunshine. It has been found by experience that a building can only be sufficiently flushed with air for sanatorium treatment when the rooms are set in a single row, with a corridor, which looks on to the open, running behind. A window of this corridor must be opposite every bedroom door, and the corridor itself must be capable of having a straight flush through by means of doors or windows at either end.

Number of stories.

The number of stories should not be greater than two, as higher buildings than this entail too much service, whilst sanatorium patients are not capable of climbing many stairs, as we can readily understand when we reflect on the fact that in raising the body vertically an amount of work is done which is equal to that expended in moving the body twenty times the distance on level ground. In other words, a climb of 60 feet, or five stories, equals a walk of 1,200 feet along level ground. Single-storied buildings add very much to the expense, owing to the necessary foundations, whilst they are not the class of building to which our patients must return when they resume their ordinary occupations. The number of stories in eighty-nine sanatoria is shown in tabulated form in Appendix No. IX., p. 170.

Avoidance of noise.

One most important point in construction is the

necessity of adopting every precaution to diminish noise. A sanatorium is like a sounding-box, for it is devoid of all carpets and nearly all hangings which can lessen the conduction of noise, and unless some precautions are adopted, as anyone with any experience of sanatoria knows, the nuisance created is a very real one. Many precautions have been tried, such as 15-inch brick partitions; double partitions, with the space between filled in with various materials; three layers of gypsdielen and two air spaces between the floors, as at Hohenhonnef; double doors, and the like. With open windows the conduction of sound can never be altogether prevented, but we consider that the difficulty is best surmounted by building all internal floors of steel girders laid on felt and filled in with concrete, the internal partitions being made of cement. This method of construction reduces the sound and is very light. The chief noise is generated in the corridors, and these should have cork carpets, which may be varnished from time to time, laid on cement. As little wood should be used as possible in construction, owing to the necessity of providing against any danger from fire.

Roof.

The roof should be flat and asphalted, as roofs of this kind avoid the usual dust-collecting space between the slates and ceiling, which can never be cleaned. Also, when repairs are necessary, they

can readily be done from boats hung from the parapets, without the erection of any scaffolding. Such flat roofs may be utilized by certain of the patients, and afford a good vantage-point for overlooking the grounds; they do not increase the heat of the rooms in summer, or add to their coldness in winter, whilst they do not permit the noise of wind or rain to be transmitted if the necessary precautions are taken.

Ground-floor.

The rooms on the ground-floor should be raised about 4 feet above the ground on the higher side of the site, to insure the privacy of the bedrooms. In several sanatoria, where the ground-floors are on the same level as the ground, there is no privacy and the comfort of the patients is considerably curtailed. By raising the rooms 4 feet a thoroughly dry building is obtained, together with a few rooms in the basement on the lower side of the building for stores, boots, and the like. Provided that these basement rooms are thoroughly dry, they are not objectionable in any way, so long as they do not communicate with the shaft of the main staircase, and so cause a draught.

Foundations.

The foundations should be of cement concrete, the depth, etc., being decided when the site is chosen. Damp-courses should be provided of slate and cement, and the ground in the neighbourhood should be efficiently drained of surface water.

Lining of walls.

The character of the lining of the walls depends very largely on the amount of money at command. We have considered this question in greater detail in connection with the description of the patients' bedrooms, and need only say here that we would advise that the floors be made of teak, with the joints well plugged and laid on cement, as this tends to make the building fireproof and at the same time sound-proof. All walls and partitions should be lined to a height of 3 feet 6 inches, or in the case of certain rooms, such as the kitchen and larder, up to the ceiling, with glazed tile work, and above this should be oil-painted, or, in the case of the block for the patients with more ample means, papered with washable paper.

Lodgment for dust to be avoided.

Where there is any right-angled junction, such as exists between the floor and the wall, the angles are to be rounded. There must be no right angles in anything, not even in the joinery work, whilst no moulded or projecting architraves should be used unless they have plain rounded surfaces, so that no lodgment for dust may exist.

Ceilings.

We would also advise that the ordinary type of ceiling, with its dirt-accumulating space underneath the joists, be not used, but that a zinc ceiling be placed directly on the under sides of the girders and fixed on a cement bed, and the zinc then painted. There are several materials on the market, such

as mezzotile, which answer this purpose admirably. The whole ceiling, if made in this way, can be readily cleaned at the same time as the walls.

Stairs.

The stairs should be made of teak, and all angles should be rounded so that they may be readily cleaned. At the London Open-air Sanatorium the staircases are built with an open space between the tread and the rise and between the stairs and the wall. A greater surface is exposed in this way to the dust, and this surface is not so readily cleaned as a rounded angle; in fact, when a stair is cleaned the dust tends to be carried through the spaces to the floor below.

Windows.

All windows should be carried flush with the ceiling, and so constructed that they are opened without effort and do not clatter in the wind. The glass of these windows should be free from ornamentation or dust-collecting ledges, and should be plate-glass.

Precautions against fire.

In addition to the foregoing, the separate blocks for the patients will have at either end of the second floor an iron bridge leading directly back to the sloping hill on which they are built. Fire-cocks will be placed, together with the necessary hose and hydrants, in convenient places in all the buildings. The value of these necessary precautions is considerably increased if the staff of the establishment is suitably trained by the regular

fire-drills which are carried out in the more efficient sanatoria.

The Personnel.

It is necessary to consider this question briefly in order that we may be in a position to determine the necessary accommodation.

Medical men.

With regard to the number of medical men, it has been found by experience that no medical officer can properly supervise more than between thirty and forty patients on the lines adopted in efficient sanatoria. Consequently, in addition to the medical superintendent, who should have supreme control, at least two other medical men will be required for a hundred tuberculous patients. As, however, during three months of the year one or other of these will be away on leave, it is advisable, apart from the possibilities of sickness and from the fact that the twelve well-to-do people may require more attention, to have a fourth junior medical man to assist when required, and to carry out the ordinary routine laboratory and record work. The medical men who have charge of the patients will not be able, according to our experience, to devote much time to research work. As research is to be a feature of the sanatorium, it will be necessary to follow Brehmer's example, and have at least one specialist in scientific research resident in the sana-

torium. We have accordingly provided in the administration block for four medical men and one research director, giving them a bedroom and sitting-room each, together with a billiard-room. These rooms (see Figs. 8 and 9, pp. 124 and 125) are cut off from the rest of the building, conveniently placed for the purposes of supervision, and in the vicinity of the special departments. If one of the medical staff marry or is married, it is best that he should be provided with a separate house; whilst anyone who may be working in the research laboratories can easily find accommodation in a neighbouring village. The medical men should dine with the patients, and so a separate dining-room is not provided for them; on special occasions, such as Sunday evening, when it is not unusual in sanatoria to relax the strictness of the discipline, they can dine in the committee-room.

Nurses.

The number of nurses required depends largely on the character of the cases admitted. Severe cases and well-to-do people require a larger number than early cases among a more necessitous class. At the proposed sanatorium in connection with the Brompton Hospital six nurses will be provided for 100 patients, most of whom will be in an early stage of the disease. As we take it for granted that cases in all suitable stages of the disease will be treated at His Majesty's sanatorium, and as twelve well-to-do patients have

to be provided for, we have decided to find accommodation for ten nurses. Two of these will reside in the block for the more wealthy patients, one on either floor, and two in the sick block, whilst accommodation is found in the administration block for six. Nurses can do much for the comfort of the patients, not only when the latter are confined for any reason to their own rooms, but especially when they first arrive at the sanatorium; whilst by dining and taking exercise with the convalescent cases the nurses can insure the necessary discipline being maintained. They can, in addition, relieve the servants of a considerable amount of work. If at any time more nurses are required for special reasons, they can readily be procured.

Other members of the personnel.

In Appendix No. VI., p. 163, we have given details of the personnel provided at some of the sanatoria for 100 or more patients. We are of opinion that it is the best plan for many of the staff—such as the clerk, the gardener, the servants who clean out the patients' rooms, and others—to reside in the neighbouring cottages. This is already the practice at many sanatoria, as, for example, at Sülzhayn. Accordingly, we have only provided accommodation, so far as the eighty-eight necessitous cases are concerned, for a secretary, a matron, a cook, ten female servants, and five male attendants. All these will have their rooms in the administration block with the exception of two of the male attendants who will sleep

in the block for thirty-six male patients, and so be ready to call a nurse or medical man in case of emergency, and two of the female servants who for similar reasons will sleep in the block for thirty-six female patients. Accommodation is also found for an engineer in the engine-house.

Staff for patients with more ample means.

The block for the patients with more ample means must have a separate staff. It is difficult to come to any decision as to the number and character of the staff for this block without knowing exactly the class of patient expected, but we have tentatively allowed for a superintendent or housekeeper, a cook, six female servants, and four male attendants.

No accommodation is provided for any patients' private servants, as all sanatorium authorities are agreed that these do much to upset the discipline, and that they sometimes do harm by smuggling in alcohol and certain luxuries of doubtful advantage.

The Patients' Bedrooms.

As we have seen, it is of primary importance that the patients' bedrooms should be easily flushed with air, so as to maintain the requisite standard of purity, and be capable of being readily ventilated from several quarters and readily cleansed.

Cubic capacity.

With regard to the cubic capacity, it is obvious that the standards drawn up for rooms with closed

windows do not apply in the case of an open-air sanatorium. The cubic space is of less importance than the size and position of the ventilating openings. Within certain limits the larger these openings are the better, so that a free circulation of air may take place without causing a draught, or encouraging what has been called the hurricane treatment. It has been said that the bedroom should be as small as possible, as it should only be used as a shelter for the bed and as a dressing-room. We have seen, however, that many patients must be confined to their rooms for considerable periods of time, so that their comfort in this matter should be considered. Again, if a room has the windows open constantly it becomes to all intents and purposes a shaft, and it is well known that the smaller the shaft the more liability there is to draught, and this is well exemplified in several sanatoria where the bedrooms have been made too small. A further objection to small rooms is the greater proportion of space taken up by the furniture, and the consequent difficulty in moving about. It will be seen further, from Appendix No. XII., p. 175, that in many sanatoria the bedrooms have a cubic capacity of 1,500 to 3,000 feet.

Height.

There is no advantage in having the rooms higher than 10 feet, although the old arguments about the air of rooms being stagnant above a level of 11 feet do not apply to a room in which the windows are

flush with the ceiling and are kept constantly open. If the room is higher than 10 feet, it is difficult to clean it methodically, whilst the windows tend to become unmanageable. It will be seen from Appendix No. XIII., p. 176, that the height of the bedrooms in various sanatoria varies from $8\frac{1}{2}$ feet to $14\frac{3}{4}$ feet.

Floor space.

The floor space must be sufficiently large to permit of the position of the bed being changed if necessary, and of the furniture being freely moved for cleaning purposes, because the air is always more or less stagnant under beds and under articles of furniture, as is shown by the great tendency of dust and fluff to collect in these positions. A floor space of 10 feet by 12 feet, according to our experience of several sanatoria where this exists, is too small for comfort, and not large enough to allow the furniture to be readily moved. The floor space allowed in a number of sanatoria is given in Appendix No. XIV., p. 177. The depth measured from north to south of a room in a sanatorium with windows only on the south side should not be more than 12 feet, on account of the necessary sunlight; when, however, fanlights are placed along the north wall, the depth may safely be 14 feet.

General dimensions of the rooms.

We have decided from the above considerations to make the individual bedrooms 10 feet high, 12 feet broad, and 14 feet deep, giving a cubic capacity

of 1,680 feet, or when the bay-window—which we shall presently describe—is taken into account, 1,960 feet. The depth rather than the breadth is 14 feet, as in this way the length of the building is diminished.

The general method of ventilation of the various buildings is considered in a separate section, but we

The ventilation.

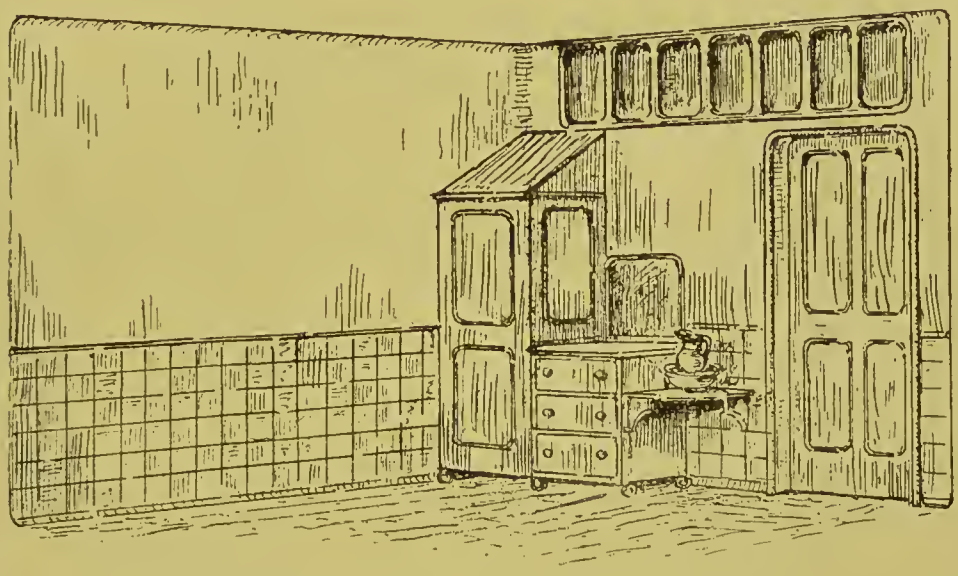


FIG. 2.—PERSPECTIVE OF PATIENT'S ROOM.

may say here that the ventilation of the bedrooms will be carried out by means of open windows and fanlights. In addition, each room will be fitted with an electric fan for use in hot weather, together with an upcast shaft with mica flap to prevent down-draught, which will be placed near the ceiling. The windows on the south will be placed 2 feet 6 inches from the floor, so that the patients when confined to

bed may have an uninterrupted view, whilst those on the ground-floor—raised 3 feet above the ground-level—will not have their rooms overlooked by

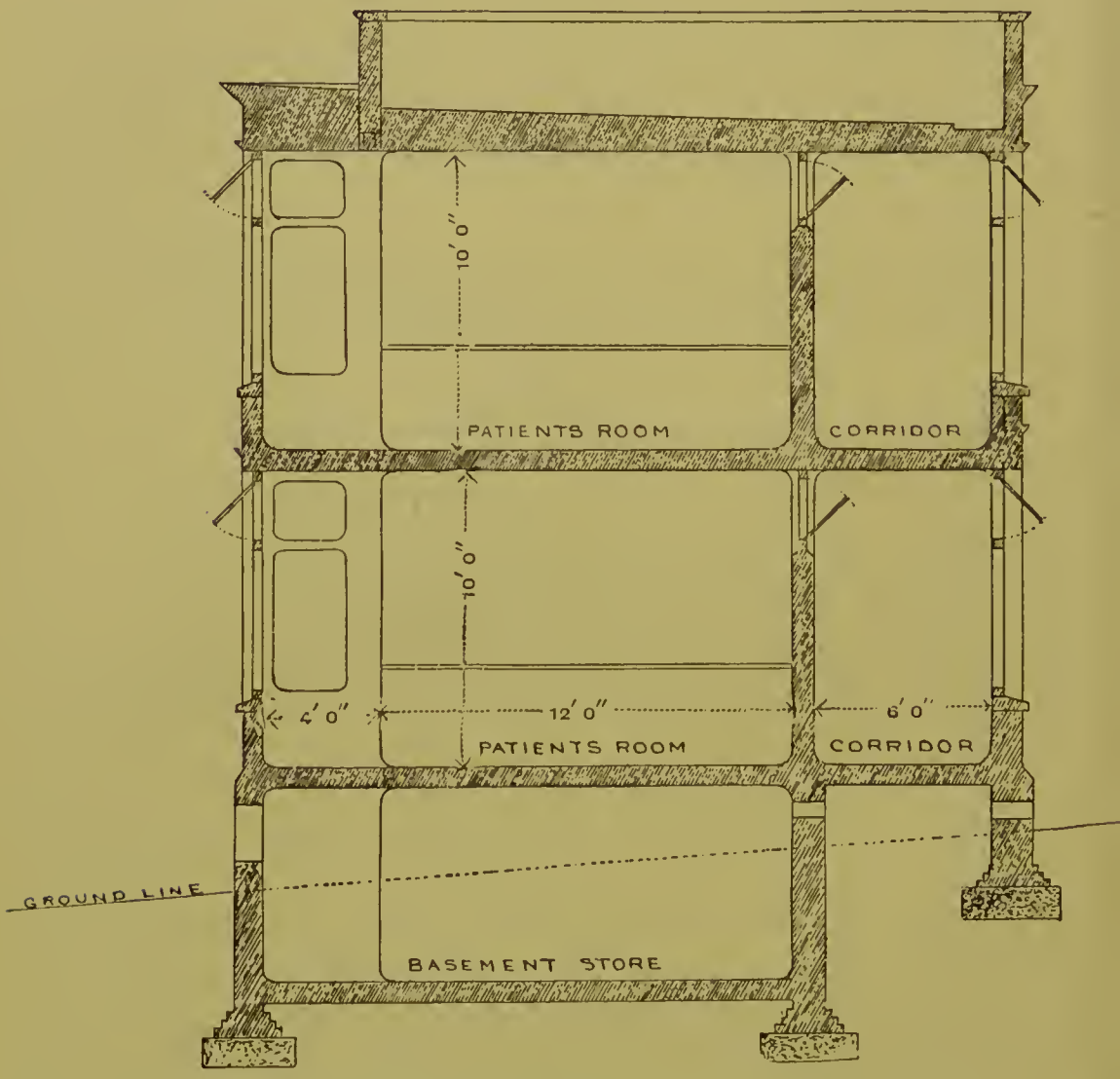


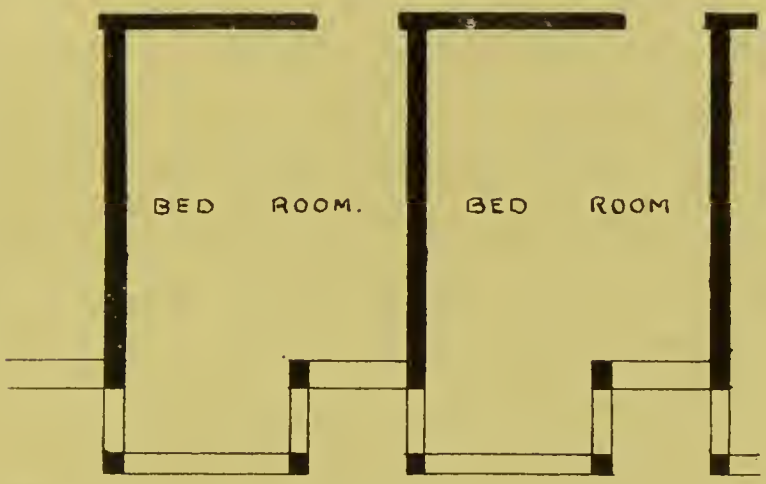
FIG. 3.—SECTION OF BLOCK FOR THIRTY-SIX PATIENTS.

passers-by. These windows will be 4 feet 9 inches high, and above them will be fanlights 2 feet high. The latter will finish flush with the ceiling,

and open outwards; they will also be hung from the top, so that the room may ventilate into the air outside and protection may be obtained against rain.

Along the whole length of the northern side are fanlights 2 feet deep and 10 feet wide, which are flush with the ceiling and open outwards on to the corridor on a hinge at their lower part, so

North aspect of room.



Scale 1 foot to $\frac{1}{32}$ *in.*

FIG. 4.

that the room ventilates into the corridor (see Figs. 2 and 3, pp. 89 and 90). The door is 3 feet 6 inches wide, in order that the bed may be readily wheeled out, and is placed opposite a casement window in the corridor.

On the western half of the south aspect of the room, and immediately opposite the door, is a casement window and fanlight 3 feet 6 inches broad. On the eastern extremity of the south side is

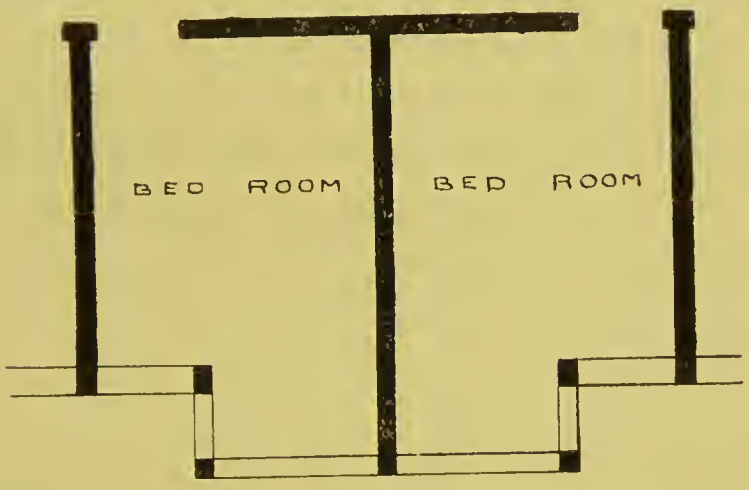
South aspect.

a rectangular projection (see Figs. 3 and 4, pp. 90 and 91) 7 feet long by 4 feet deep. The northern side of this projection is open to the room, but all other aspects of it are enclosed by windows, such as those described, one casement looking east, one west, and two in a southerly direction. This projection affords ample space for a sofa-chair, and in our opinion is an ideal place for those patients who may be isolated and confined to bed, and for all patients during the hour they are resting before the mid-day and evening meal. In addition, it affords a ready means of acclimatizing patients, especially the more elderly, to an open-air life. No matter what wind blows, the window on one or other aspect can be opened without harm, whilst, when the patient rests in this part of the room, the other portion can be flushed out by a direct draught between the western (or eastern) window and the door. In our opinion, these projections afford the most efficient means by which a patient, when in his room, may enjoy a free circulation of air and yet be protected from the weather; they will be 5 feet apart, and no patient, although able to see from one projection to another, will be able to overlook the interior of the neighbouring rooms to any appreciable extent. Naturally, they add somewhat to the cost of construction; if the amount of money at command is limited, two projections may be thrown into one, so that one loses its

eastern and the other its western aspect (see Fig. 5). If the projection thus curtailed is still too costly, we must revert to straight walls, and depend on the ordinary windows for the necessary free circulation of air.

Protection against wind, rain, and sun.

In most sanatoria some provision is made against wind, sun, and excessive rain in the bedrooms and elsewhere by means of screens, which are



Scale 1 foot to $\frac{3}{32}$ in.

FIG. 5.

also of service in the case of patients who cannot sleep unless the room is darkened. Schrader discarded venetian blinds, as they collected dust and were unsuitable, and the same objection holds good of various forms of storm-shutter. We would recommend roller blinds, such as are used in shops, of greenhouse shading, a material which prevents the entrance of excessive rain and serves to check the too rapid passage of air, although it

allows free ventilation. This material can readily be removed, cleaned, and disinfected.

Lining of the walls.

The chief considerations to be kept in view when choosing the material for lining the walls are that it should be readily cleaned without entailing much service, and that it should not be depressing in character. The walls of the patients' rooms are not very liable to infection in a building where the patients are carefully trained to dispose of their sputum, but the fact remains that by carelessness or accident the walls may be infected. As we have seen, numerous researches on this point have been carried out, but practically all agree with Coates, who has shown that, when the walls are infected with sputum, it is nearly always within 1 or 2 feet of the floor. This is an important observation, as it shows the necessity of providing an easily cleansible lining material in the immediate neighbourhood of the floor. Various materials are employed in existing sanatoria—tiles, oil-paint, ordinary distemper, washable distemper, duresco, petrifying fluid, wood, and various forms of paper, such as ordinary paper, washable linen paper, and washable muraline paper with a canvas backing. Wood is apt to crack and the joints to harbour dust, whilst it is difficult to join thick paper in a satisfactory manner. There are, however, many materials adapted to our purpose, and the question

of what lining should be used depends largely on the amount of available money. Some forms are cheaper in their initial cost, but require to be renewed at frequent intervals. There can be no doubt that the form of wall-lining which is most readily kept clean and entails the least service is tiling efficiently laid. There are many forms of artistic tiling on the market which do not make a room look cold, and although the initial cost is greater than of some other materials, yet tiling lasts better than any other material. We therefore advise that the walls of the rooms should be lined with glazed tiles to a height of 3 feet 6 inches—that is, to the height of an ordinary chair. About 1 inch below the top line of the tiling a small well-rounded projection may be allowed, as this gives a finish and prevents scraping of the lining material above when the upper portion of the tiles is cleaned. We would recommend oil-painting as the most satisfactory lining above the tiles, unless there is sufficient money at disposal—as, for instance, in the case of the block for patients with more ample means—to provide for the more frequent renewal of washable papers, which do much to add to the cheerfulness of the room. The colour of the tiling should be varied in the different rooms, in order to avoid any monotonous effect.

We have already dealt with the character of

Ceiling.

the necessary ceiling in the section on structural details.

The floor-covering.

A large number of materials are used in sanatoria for the construction of the floors, such as wood, which may be hardened and polished by a mixture of paraffin and benzine; various forms of tiling and terazzo; fossil wood or xylolith; linoleum; cork carpet, which may be varnished; torgament, a cement which unites with wood or iron, and has incorporated with it wood shavings, so that it is both cleanly and warm to the feet; and gypsdielen, which is usually covered with linoleum or parquet, and consists of bamboo incorporated with plaster of Paris. Linoleum is the cheapest of these, but we have never seen it in use without noticing a number of cracks, to say nothing of the dust which collects at the margin near the wall. Again, condensation always occurs beneath linoleum, and is one of the commonest causes of dry-rot; the placing of felt beneath the linoleum does not diminish either this or the collection of dust. We consider that, of the hard coverings, a teak floor laid on cement gives the most satisfactory results and lasts better than any other material. At the junction of the floor and walls there must be a bold curve in the tiling, so that dust may readily be removed, and furniture, such as the bed, may not abut on the walls, and in this way interfere with the free circulation of air.

General requirements of furniture and hangings.

The furniture must be light, and free from unnecessary ornamentation, mouldings, or dead space. It is important that it should be readily cleaned, and that the under surface of any article should not escape this process. It should be smart in appearance, for smartness leads to cleanliness. The bed should have rubber casters, and the legs of other furniture should be capped with rubber, as this prevents the floor from being marked and does away with much noise. There is no absolute necessity for a carpet, provided suitable slippers are used, but one small mat of cane or other readily disinfected material conduces to comfort whilst dressing. The hangings must be simple and readily washed. Pictures add to the cheerfulness of rooms, but they also add to the service as they must be kept free from dust, and consequently, although they may be permitted in the recreation and dining rooms, they should not be allowed in the bedrooms unless an ample staff can be provided, or there is sufficient money at command to arrange for their being let in flush with the walls.

Whether wardrobes and cupboards should be provided.

It is undesirable to have bags and boxes in the bedrooms, so that some form of receptacle must be provided. Chests of drawers probably meet all requirements, but it is usual in sanatoria to have either a cupboard or a wardrobe; the former are more expensive as regards construction, but they

encroach less on the cubic space of the room ; both are open to the objection that they are not readily cleaned.

Other necessary articles of furniture.

We suggest that, in addition to a bed, two small chairs, a sofa-chair in the bay-window, and a bed table with glass or marble top, a special piece of furniture should be provided. This latter may consist (see Fig. 2, p. 89) of a hanging cupboard for clothes, a chest of drawers and a washstand combined, together with a fixed plate of glass, as swing or hanging glasses tend to collect dust. It should be built on rubber casters, so that it may be easily moved every day and the whole readily cleansed. We would advise that neither the cupboards nor the drawers have any back, so that they can be readily cleaned out. The top of the cupboard should be sloping, all angles rounded off, and there should be no moulding or other ornamentation which would serve as a lodgment for dust.

Whether douches or lavatory basins should be placed in these rooms.

In some sanatoria, such as Nordrach, each room is provided with a douche and with two fixed lavatory basins, one being used when the mouth and teeth are washed. The presence of a douche in the room is an extremely convenient arrangement, occupies little space, and involves the minimum of strain on the patient; but English sanitary authorities almost unanimously condemn it, more especially

when there is not the high water-pressure of Nordrach, on the ground that the pipes and traps become almost as foul as soil-pipes. In view of this, we have arranged the bathrooms in the sanitary tower, which we shall presently describe.

Method of lighting.

The rooms will be lighted by electric lamps, one of which will be placed over the washhand stand and controlled from the door, whilst the other will be attached to a wire, so that it can be used in any part of the room.

Means of communication.

The electric bells, one placed near the door and the other on a length of wire, in order that it may be available at the bed or sofa-chair, will be so arranged that a nurse may be summoned at once by day or night.

It will be seen from the plans that recesses are provided in the corridors, with a northern aspect, to which those patients who are isolated may retire when their rooms become uncomfortably hot in summer.

The Ventilation Arrangements.

The percentage of carbon dioxide.

We have shown in the previous pages that the ventilation of the buildings should be such that the air within them constantly rivals the outside air in point of purity. This is a higher standard than the one adopted by most sanitary authorities for ordinary buildings on the basis of Parke's work. Most authorities accept as a standard of purity a per-

centage of 0·06 of carbon dioxide. This is too high a percentage for tuberculous patients, and Rufenacht Walters, in a paper read at the recent London Congress on Tuberculosis, showed that it was possible to keep the percentage of carbon dioxide in a sanatorium bedroom, inhabited for many days by a feverish patient, almost as low as that of the outside air. The rules for good ventilation as laid down by many authorities nearly all apply to rooms with closed windows. When the windows are kept constantly open ventilation is much easier, more especially when cross-ventilation can be obtained by means of an open door and fanlights on the wall opposite the windows. The inlet must be sufficiently large to prevent a draught, for air, like water, tends to rush through a small opening, and so cause a draught, whilst with the same pressure it will pass quietly through a larger opening.

Methods of ventilation.

Appendix No. XVI., p. 179, gives a tabulated statement of the various forms of ventilation used in seventy-six sanatoria, and it will be seen that some authorities trust entirely to open windows with or without fanlights on the opposite wall, others to open windows with various forms of ventilating inlets or shafts, and others to open windows with cold or warm air forced in, whilst a few utilize open fires or chimneys in addition to the open windows. We may say at once that the plenum system must

be condemned; it was tried at Nordrach, at the Ventnor Hospital, at the National Consumption Hospital, Ireland, and at the Forster Green Sanatorium, and in all cases given up as useless. We have said enough in previous pages to show that no system of forcing heated air into the rooms is good. Open fires are most useful ventilators in ordinary houses, but, as may be seen from Appendix No. XVII. (*a*), p. 181, in which we discuss the relative value of various methods of heating, they are not of service in sanatoria. They give rise to dust both when burning and when being cleaned, and on this count alone must be condemned; again, when the windows are widely open sudden gusts not infrequently blow the smoke into the room. We have, therefore, decided to ventilate the patients' bedrooms in the manner already described in the account of these rooms. The larger rooms and any part of the building where air is likely to become stagnant or foul will be ventilated by electric fans and shafts in addition to open windows. In summer time the doors of the bedrooms, each of which is placed opposite a corridor window, may be opened and the passage of air from the cooler side of the house facilitated.

The Heating and Cooking Arrangements.

The employment of electricity.

In the earlier pages we showed that in constructing a sanatorium every means must be taken against the formation of dust, and that the use of coal should be avoided as far as possible. The only way in which the use of coal can be completely avoided is by means of electricity, generated by water-power or by means of oil or gas engines. At many sanatoria coal is not used in the patients' quarters, but is employed in the engine-house for the purpose of generating electricity. In such cases dust must always be discharged into the atmosphere, and in our visits to some of these sanatoria we have never failed to obtain evidence of the presence of a large amount of dust in the atmosphere by the simple expedient of running our fingers over various articles in the patients' rooms. In our opinion electricity should be employed as much as possible in all sanatoria. The way in which electricity is generated must depend on the natural advantages of the site. A sufficiently abundant water-supply affords an ideal means, but failing this we must have recourse to oil or some form of gas. The use, however, of electricity generated by oil on a large scale is expensive. If gas is utilized, it may be taken from the ordinary mains when these are available, but otherwise one of the forms of gas which can be

made without the use of coal should be manufactured at some little distance from the sanatorium buildings. Electricity can be economically employed not only for warming the patients' rooms, but for laundry purposes and for cooking. We show in the specification on this subject (see Appendix No. XVII. (*b*), p. 185) the use we propose to make of this means of heating. As it is not conducive to economy to heat the water required for the steam-disinfector, for baths, lavatories, or for the laundry, by means of electricity, we propose to use small upright boilers for this purpose. These boilers will be supplied with coke, and will have efficient smoke consumers attached to them. In the case of the patients' blocks they will be placed in the basement under the sanitary towers, with a shaft carried up the towers well above the level of the roof, whilst the necessary flow and return pipes and draw-offs will be confined to the towers as far as possible.

Coke boilers.

The bedrooms of the patients do not require any artificial warming for many months in the year, and when such artificial warming is used, we have shown that the temperature of the rooms should not be much higher than that of the outside air. At the same time, if the temperature of the rooms is a little higher than that of the outside air much is done to insure good ventilation. As may be seen from Appendix No. XVII. (*c*), p. 188, on this sub-

Radiators.

ject, the temperature of the rooms at many sanatoria, such as Rudgwick and Rossclare, is kept at the temperature of the outside air in the winter, no artificial heating being used at all ; in others, such as Linford, the Grampians, Adirondack, and Boserup, the temperature is never allowed to exceed 50° F. The small increase of temperature required is readily given by many of the electric radiators on the market. By utilizing these we avoid a considerable amount of initial expense in the matter of pipes, etc., whilst the annual cost of maintenance, redecoration, and service is also much less than in the case of any hot-water or steam system. Electric heating is used in some rooms at Nordrach-on-Dee and in one villa at the Nordrach Colonie, and in both cases gives satisfactory results ; it is also to be installed in the proposed sanatorium at Liverpool. The position of the radiator is of importance, for no attempt should be made to warm the incoming air, as this interferes with its humidity and destroys the ozone, and the attempt ends in failure where open windows are used.

We show in Appendix No. XVII., p. 180, the various forms of heating apparatus used in over 100 sanatoria, and in Appendix No. XVII. (*a*), p. 181, discuss the advantages and disadvantages of the various methods used. In some sanatoria, open fires are provided for the staff, although the

patients are not allowed to have them. There is no reason why the staff should have open fires. The absence of these cannot be regarded as a hardship, seeing that to all intents and purposes they are not used in any country except England. In those sanatoria in which an exception is made, and the staff are allowed coal fires, we have noticed that dust collects in considerable quantities. Finally, in most sanatoria, as time goes on, a large proportion of the staff consists of former patients who are better without open fires.

Open fires.

The Lighting Arrangements.

There is no doubt that electricity affords the ideal means of lighting in any building which is specially devised for the reception of people in ill-health. It gives a most efficient light, does not overheat the rooms, and does not lead to the formation of noxious products in the air, whilst it is easily regulated, always available, and saves much expense in the way of redecoration. All rooms in the proposed sanatorium, together with some of the shelters and the covered way, will be fitted with electric light. The lights will be suitably placed for the varying requirements of the rooms and passages, whilst the greater number in the passages, corridors, etc., but not in the patients' bedrooms, will be controlled from the central station, so that, for the sake of economy,

The employment of electricity.

they may be simultaneously turned off at certain hours, only sufficient light being left in the corridors and other places for special emergencies.

General Dining and Kitchen Arrangements.

For the more wealthy patients.

As the patients with more ample means will necessarily expect superior arrangements and a better cuisine, their block is provided with a separate kitchen and dining-room. We need only mention here that both the dining-room and the kitchen premises in this block are entirely cut off from the patients' rooms by cross-aerial ventilation. With regard to the dining-room and kitchen accommodation

For the more necessitous patients.

for the more necessitous patients, we have already pointed out that this must be completely cut off from the patients' bedrooms. Appendix No. VIII., p. 169, shows that this is done at a number of existing sanatoria. We find that at the Royal National Hospital at Ventnor, and elsewhere, the provision of a dining-room and kitchen for each separate block has proved wasteful, and therefore we have provided (see Fig. 8, p. 124) one dining-room and kitchen in the administration block for all those patients who are able to take exercise. These premises are cut off by efficient ventilation from the other portions of the block, and, as will be seen, there are arrangements by means of suitable doors for completely cutting off the corridor—

running behind the dining-room and in front of that part of the building which contains the kitchen and other offices—from the rest of the building when meals are being served.

For patients confined to bed.

The patients who are confined to bed are better without any kitchen in the vicinity, as it is difficult to control the ventilation effectually and to keep the air pure ; consequently, their food is to be cooked in the administration building, and then transferred by means of Swedish cars to the various blocks. That Swedish cars effectually keep the food hot, and do not lessen its palatability at all, is shown by the fact that many people in London and elsewhere patronize them for dinner-parties and other entertainments, whilst cars of very similar construction are frequently used at shooting-parties to provide a hot luncheon. Patients in bed will further require their food to be served on hot-water plates, as they often spend some little time in negotiating a meal. We have considered whether the food could be conveyed from one building to another by means of a pneumatic tube or railway contrivance, but the estimate given by the engineers whom we consulted shows that the cost would be prohibitive ; and, indeed, there is no occasion for anything of this kind, as the Swedish cars meet all the necessary requirements.

The Drainage Arrangements.

Disposal of sewage.

Whether we dispose of the sewage by conservancy methods, by the water-carriage system, or by some form of tank treatment must depend to a very large extent on the character of the ground on which the sanatorium is built, and upon the facilities afforded in the neighbourhood. We will, however, mention some of the arguments for and against these various systems. All sanitary authorities are agreed that

Earth-closets.

the best conservancy system available is the one which employs earth-closets. This system has been adopted in several modern sanatoria, such as the East Anglian, and there can be no doubt that it is a very good one from a sanitary point of view, for the reasons that it does away with all pipes and with the possibility of leakage, and that there is no delay in the disposal of the excreta. Vivian Poore has pointed out that it is of value for various agricultural and financial reasons, whilst closets with automatic arrangements for supplying the necessary earth which are easily worked, practical in construction, and not liable to disarrangement, are on the market. Lortet and Despeignes have shown, however, that the earth-worm brings tubercle bacilli to the surface, and that these may be a source of infection, and Galtier of Lyons has proved that the bacilli may resist putrefaction in earth for months.

Gärtner buried the bacilli for one year, and found that they remained virulent ; whilst Shottlius claims that they remain virulent for as long as two years. Again, Biggs of New York and Flick of Philadelphia have shown that the soil on which houses inhabited by consumptive individuals have stood has become infected. This difficulty might be overcome by freely exposing the excreta to sunshine for several days before digging in, or possibly by the addition of disinfectants, but both these methods are open to practical objections. Further, the earth-closet system is open to the following objections : it requires a special form of soil ; the cost of the cartage and the supply of suitable earth, of preparing the same by suitable drying and passing through sieves, and of providing men to carry earth and to empty the pails, is considerable, apart from the cost of the kind of land necessary for distribution ; whilst a nuisance may be readily created, more especially if earth-closets are used on any story above the ground-floor.

Water-carriage system.

We advise, then, that the earth-closet system should not be adopted. We consider that the water-carriage system, if a sewer is available in the neighbourhood, is the best method we have for disposing of the sewage, as by this means the sewage is kept moist and the tubercle bacilli are gradually destroyed by other micro-organisms, while there is no danger of any escape of the putrefactive gases provided that

the necessary work is efficiently carried out. In Appendix No. XIX., p. 208, we have given an expert's specification for the installation of this system in connection with the buildings. If the water-carriage system is not available, we recommend the adoption of the biological process of Cameron, which, as we have shown in Appendix No. XIX. (*a*), p. 211, is the best of the tank methods.

Tank methods.

Disposal of slop water.

In the country it is desirable that the slop water should be turned on to the land in some form or another, more especially if the biological method of disposing of the sewage is adopted, as it not infrequently interferes with the efficient working of this process. We recommend the adoption of Kenwood's system of sub-irrigation, which, as we have shown in Appendix No. XIX. (*b*), p. 216, is the best method for disposing of slop water. The waste from the kitchen and pantry sinks must be efficiently strained and filtered.

The Lavatory, Bathroom, and Water-closet Accommodation.

General fittings.

All sanitary fittings, as may be seen from the specification given in Appendix No. XIX., p. 208, will be of the most modern type.

Urinals.

No urinals will be provided in any part of the sanatorium, as these are filthy contrivances at best,

and there is no necessity for them where lift-up water-closet seats are employed.

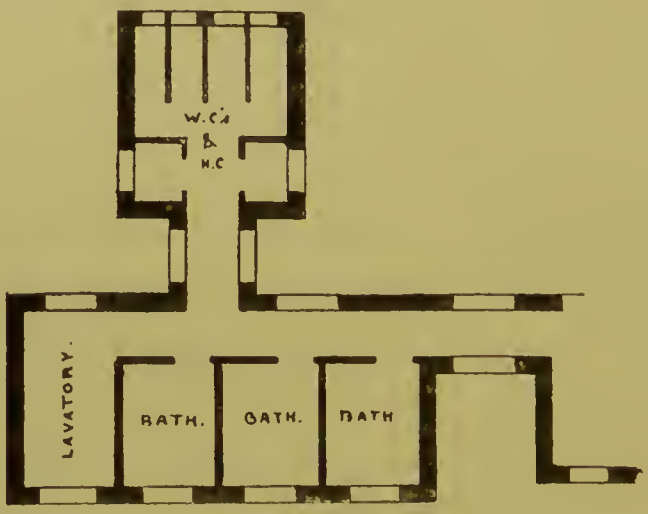
Administration block.

In the administration block (see Fig. 8, p. 124), a male and a female lavatory are provided for the patients in the immediate vicinity of the entrance-hall, together with water-closet accommodation, which is well cut off from the lavatory by cross-aerial ventilation. As may be seen from Figs. 8 and 9, pp. 124 and 125, the necessary sanitary accommodation for the personnel is thoroughly cut off from the patients' rooms and conveniently arranged as follows : Two water-closets, two bathrooms, and a lavatory for the medical staff, a separate closet and bathroom for the secretary, a separate closet and bathroom for the matron, two closets and two bathrooms for the nurses, two closets and one bathroom for the female servants, together with two closets and one bathroom for the male servants.

Sanitary towers in patients' blocks.

With regard to the patients' blocks, the sanitary arrangements are grouped together in sanitary towers. The position of these towers is a matter of importance. Wherever possible, they should be placed at the end of the building, as they afford considerable shelter in this position to a house which consists of two wings joined at an angle of 145°, and are less likely to ventilate into the corridors or bedrooms than if they were placed, as they are in some sanatoria, at the back of the corridor. Therefore

these sanitary towers should be placed at either end of the hospital block and of the house for the patients with more ample means. Whether the towers can be placed at the ends of the blocks for thirty-six patients depends on the character of the cases treated, but as patients in these blocks will be in a convalescent stage the extra length of corridor which must be traversed in going to the bathrooms or elsewhere is not a great disadvantage.



Scale 24 feet to 1 inch. FIG. 6.—SANITARY TOWER.

The accompanying plan (Fig. 6) shows the way in which these towers are cut off from the rest of the buildings, and the manner in which the accommodation is distributed. All portions of them will be ventilated by open windows and by extractor fans. In the blocks for thirty-six patients there will be on each floor of a sanitary tower three bathrooms, and four water-closets in addition to a lavatory and housemaid sink accommodation. In the block for the severer

cases, two water-closets and two bathrooms are provided on each floor of the sanitary towers, together with lavatory and other accommodation. In the block for the well-to-do ample provision is made for the patients and for the staff. Each lavatory in the separate houses can be used as a hair-cutting room, and in view of the fact that hair-cutting causes much dust (so much so that the trade of hairdresser stands high in the mortality rate of tuberculosis), special ventilation of these rooms will be provided.

The Measures which should be taken to destroy the Tubercle Bacilli.

It is necessary to consider this part of the subject in order that we may decide what constructive details have to be provided with regard to disinfection. We have shown that tuberculous individuals may readily spread virulent bacilli, but that if reasonable precautions are adopted this danger may be avoided. Thus, Achtermann, who for many years was in the habit of testing the dust from corridors, rooms, and other places at the Brehmer Sanatorium by means of inoculation experiments, only once found any evidence of the presence of tubercle bacilli. We must, however, bear in mind that in a sanatorium patients may not always conform to the regulations, and therefore we must be ready to

cope with any infected material, such as clothing, furniture, and other articles, more especially as our patients have already demonstrated that they supply the necessary soil for the growth of the bacilli. We have given in Appendix No. XVIII., p. 189, a summary of a number of experiments on the best means of rendering tubercle bacilli innocuous, whether in sputum, dust, furniture, or clothing, together with a tabulated summary of the various methods adopted in a number of sanatoria for collecting and disinfecting the sputum and for disinfecting the clothes, crockery, rooms, and furniture.

Summary of experimental evidence.

We will therefore content ourselves with a very brief review of this part of the subject before mentioning the conclusions we have formed. In the first place, it has been shown by many observers, such as Schill and Fischer, Steinitz (1901) and Elliott (1902), that it is practically impossible to destroy tubercle bacilli in nummular sputum within a reasonable time by boiling for a short period, or by any chemical means, except by the use of chlorinated lime. Delépine states that a 2 per cent. solution of chlorinated lime is efficacious when mixed with an equal quantity of sputum. Elliott treated nummular sputum with solutions of perchloride of mercury (1 in 500) and carbolic acid (1 in 20) for twenty-four hours, and then injected the central portion of the mass into

guinea-pigs. All of these animals died subsequently from tuberculosis. Moeller boiled nummular sputum for ten minutes, and then injected the central portion of the larger masses into animals, all of which developed tuberculosis. These results are due to the fact that the albumin of the nummular masses becomes coagulated by the action of heat or of the chemical substances, and so forms an almost impermeable envelope, which tends to protect the central portions of the large masses from the disinfecting agent. It is shown in the appendix on this subject that the only practical methods by which we can destroy the larger masses of sputum, are either by means of incineration, boiling in water to which sodium bicarbonate has been added, or the use of chlorinated lime. The addition of sodium bicarbonate to water raises the boiling-point to 102° C., and either prevents the coagulation of the albumin or dissolves the albuminate which is formed. In a sanatorium such large masses of sputum should always be collected in some form of flask. It is only the small stray drops which are likely to infect the clothes, furniture, and walls ; and, as may be seen in our appendix, these small drops may be rendered innocuous in a variety of ways.

The conclusions we have drawn are as follows : The sputum.

1. The hands, beard, and hair must be kept scrupulously clean, and the patients must be instructed

always to place a handkerchief in front of their mouths when they cough, and never to expectorate anywhere except into some form of flask or other receptacle. Fortunately, most patients rapidly lose their cough under sanatorium treatment, especially if they are told that the act of coughing is detrimental to them, although they continue to get rid of a certain amount of expectoration. Also, in view of the numerous observations on the infectivity of spray from the mouth made by Heymann, Flügge, Boston, Nenninger, and others, to which we have referred, it is imperative that consumptive patients should take the most scrupulous pains with regard to the cleanliness of their mouths. Handkerchiefs must not be used to spit into, but only to wipe the mouth, and they should be carried in a special pocket or bag, with an indiarubber or oil-silk detachable lining which can be disinfected readily; for, as y Capo has said, a pocket which contains a handkerchief soiled, it may be, with mucus, sweat, or saliva, affords a veritable breeding-ground for many forms of micro-organisms. Both handkerchiefs and napkins should be of Japanese paper, or some cheap material, such as calico strips, so that they may be burnt. The well-to-do may have ordinary handkerchiefs—provided that they are frequently changed, as paper handkerchiefs are not pleasant things—and napkins, if clean at every meal, as these may readily

be disinfected in the steam disinfecting station which we propose to place in the engine block. When in their rooms, patients should spit into receptacles made of papier-maché. This is sufficiently thick to require no outer covering of metal. The top must be so constructed that flies cannot disseminate the material. Such cups are cheap, and are already in use, as is shown in Appendix No. XVIII. (*a*), p. 199, at six sanatoria. The cups should be filled to one-third with a mixture of lysol and soap, as this tends to mitigate the repulsive appearance of the sputum, and to prevent drying and dissemination, whilst both Gerlach and Spengler have shown that lysol effectively diminishes the virulence of tubercle bacilli. The paper cups should be removed each day to the electric incinerator, which we propose to place in the basement of one sanitary tower in each block, and there mixed with sawdust and burnt. By this means the sputum is not constantly being carried through the grounds, as at some sanatoria. When the patients are out of their rooms, they should expectorate into a Dettweiler, Guelpa, or other flask, or any similar contrivance which can readily be hidden within the folds of a handkerchief, and which cannot spill its contents. These flasks should be collected every evening and removed to the incinerating-room, and there dealt with as follows: The contents should be mixed with

sawdust in an iron receptacle and then burnt, whilst the flasks themselves may be treated as they are at the Bichat Hospital. At this hospital they are placed in a copper containing water, to which sufficient washing soda has been added to make it strongly alkaline; the water is gradually raised to the boiling-point, and kept there for ten (better thirty) minutes. The flasks are then washed out with water and stored for use. Or they may be dealt with as they are at the Hauteville Sanatorium —namely, placed in an autoclave, and submitted to a temperature of 120° and a pressure of 2 atmospheres for half an hour. The vapour flows in and out of the flasks, which are thus mechanically washed. They are then thoroughly washed with cold water and dried in hot air.

he walls
nd floors of
ne rooms
nd passages

2. All cleansing of the walls and floors must be by means of wet cloths, as other means do not remove the dust but simply displace it. It has been said that the sound of a brush or a broom should no more be heard within the walls of a sanatorium than was the hammer within the sacred precincts during the building of Solomon's Temple. The floor of the patients' bedrooms and the glazed dado should be wiped daily with a damp duster, moistened with a solution of 1 in 100 chlorinated lime. The floors may be subsequently polished. The dusters must be periodically burnt.

The walls above the dado are extremely unlikely to be infected in a sanatorium where patients are properly educated in dealing with their sputum, as has been proved by the researches of many observers, and a periodical thorough scrubbing with soap and water has been shown in many hospitals to be all that is required. When a patient vacates his room, it may be well to rub it down with bread, which should be afterwards burnt. If, however, there is any reason to suspect that mucus has been expectorated on to the walls, it is better—in view of the fact that Coates has shown bread to be useless when there is any sticky mucus on the walls—that these should be moistened and disinfected by formaldehyde, provided that a Trillat's autoclave is used. With other methods formaldehyde is of no service, and comes under the same category as all other gaseous methods of disinfection, which, according to a pamphlet on this subject of the National Association for the Prevention of Tuberculosis, are inefficient.

Furniture.

3. Furniture should be well wiped with a duster moistened with a solution of 1 in 100 chlorinated lime, as Delépine states that this agent does not injure furniture if the latter is subsequently wiped with a duster moistened in water. It should be of such a nature that but little dust collects, and of such materials that it can be readily disinfected. For example, most forms of stuffing or of carpet cannot

be satisfactorily dealt with, and leather is readily injured in the process, whilst linen covers, washable leather, and wickerwork may readily be disinfected.

Linen.

4. Linen, the coverings of cushions, and the like, must be collected in suitable receptacles, the linen being collected every day, and taken to one room of a disinfecting-station; all should be thoroughly soaked in cold water, in order to remove various stains which treatment with steam tends to fix, and then passed through a steam sterilizer, and finally dealt with in the laundry.

Ordinary clothes.

5. Ordinary clothes, small mats, wicker chairs, mattresses—which should be made so that they can be unpicked readily—and other similar articles, may be efficiently disinfected in the same steam sterilizing apparatus.

Articles which cannot be sterilized by steam.

6. Such articles as books, leather, wool, silks, brushes, combs, and other articles which are damaged when sterilized by heat, may be treated with formic aldehyde generated in a Trillat's autoclave.

Crockery, knives and forks.

7. Crockery, knives and forks, and the like, can be sterilized in an ordinary surgical sterilizer by gradually raising water to which sodium bicarbonate has been added to a temperature of 102° C., and then keeping it at this temperature for at least twenty minutes.

8. Infected rags, paper, old mattresses, pillows, dusters, etc., which are no longer required, together with the various forms of dust and refuse, and their receptacles, should be dealt with in a dust-destructor attached to the engine-house. Old articles, dust, and refuse.

9. Bedroom and other slops probably do not require to be disinfected; at most, the various utensils may be periodically scalded. Bedroom and other slops.

We see, then, that so far as the structure of a sanatorium is concerned we must have—

1. A disinfecting-station. This we have placed in the block which provides accommodation for the engines and the laundry. Necessary accommodation for disinfection purposes.
2. A room in the basement of a sanitary tower in each block where the sputum and handkerchiefs may be burnt, and flasks and other articles sterilized.
3. A place where other substances, such as refuse and the contents of dust-bins, may be dealt with in a dust-destructor. This we have provided in the engine block.

Facilities for Observation and Research.

A laboratory (see Fig. 9, p. 125) together with a record-room, is provided in the immediate vicinity of the quarters for the medical men, for the routine examinations of various materials, such as Observation.

sputum and urine, whilst separate rooms, with waiting-hall attached, are placed on the ground-floor of the eastern wing of the administration block (see Fig. 8, p. 124) for the X-ray, dental, and throat departments, which experience has shown are necessary in a large sanatorium. It has been found

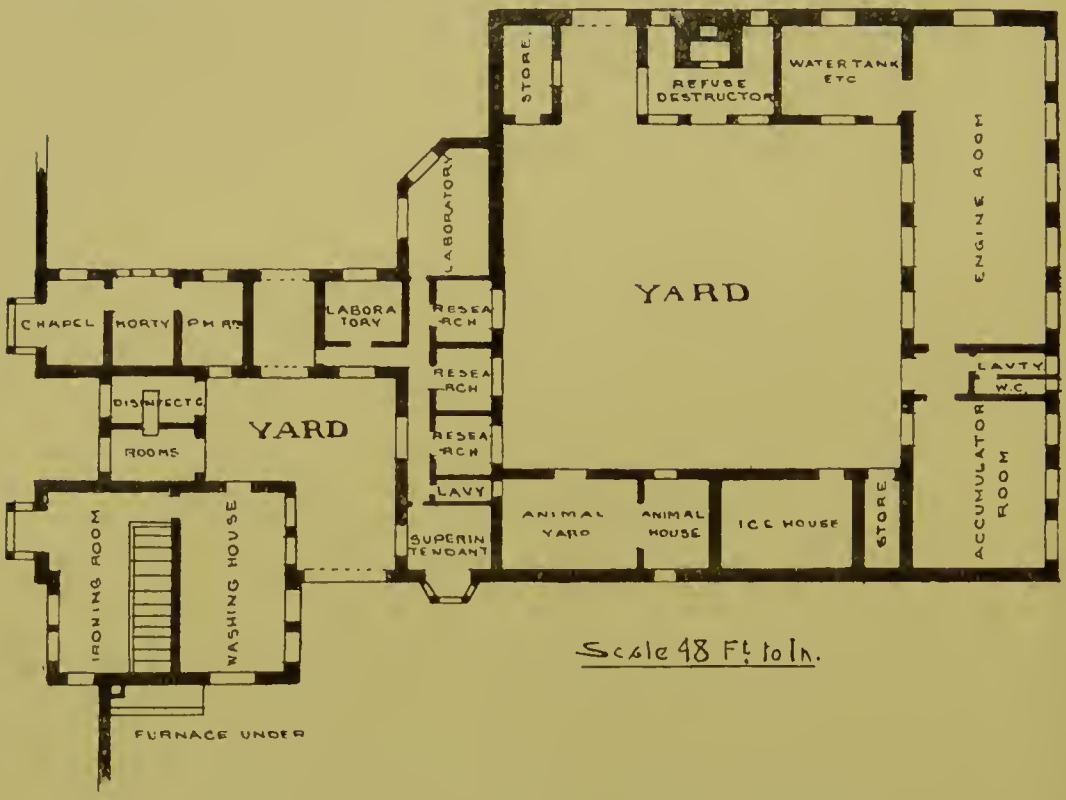


FIG. 7.—ENGINE-HOUSE, LAUNDRY, RESEARCH-ROOMS, ETC.

that the routine examination of patients by the physician is most satisfactorily carried out in the individual bedrooms, but these special rooms may be used for consultation purposes when the occasion arises. The number of these rooms, as may be seen from the figure, may readily be increased if any new form of treatment or observation is devised in the

future. The sick block is provided with an operating theatre and its necessary adjuncts (see Fig. 12, p. 131).

Research. The sanatorium is to be equipped with all requirements for scientific research, and we have come to the conclusion that any experimental work is best done as far away as possible from the patients' buildings, and have accordingly grouped the necessary rooms in the laundry and disinfecting block, but in such a position (see Fig. 7, p. 122) that they are free from any liability to the vibration which may be caused by the engines. The rooms will consist of a laboratory for bacteriological and pathological research which is in communication with the post-mortem room, and a laboratory where chemical, physical, and physiological problems may be worked out. In the immediate vicinity of these laboratories are three small research-rooms, together with a director's room, which will also serve as a record-room and library. Attached to the same block is a well-ventilated animal-house, without which many of the scientific questions which will arise cannot be elucidated. Meteorological requirements are met by the provision of various instruments mentioned in Appendix No. XX., p. 218.

FIG. 8.—ADMINISTRATION BLOCK. GROUND FLOOR.

FIG. 9.—ADMINISTRATION BLOCK. FIRST FLOOR.

The Laundry Arrangements.

Ample accommodation (see Fig. 7, p. 122) is provided for laundry purposes in the same block as the engine-house, the disinfecting-station, and the research laboratories. The washing-room is in direct connection on the one side with the room in which various articles, such as linen, are placed *after* disinfection, and on the other with a drying-chamber of the most modern type. The drying-chamber communicates directly with the finishing-room, and this in turn with the outside. All laundry work will be done by electricity, as may be seen from Appendix No. XVII. (*b*), p. 185.

Short Description of the Various Buildings.

The details of the various buildings which have not yet been described will be most readily grasped by a reference to the individual plans in which the character of the various rooms is specified; we will, however, briefly refer to the leading features of each :

Administration block.

1. The administration block (Figs. 8 and 9, pp. 124 and 125) has a southerly aspect and consists of a central portion and two wings, whilst a corridor which leads to the open air at either end, runs from east to west through the entire length of the building. On the southern side of the central portion, on the ground-floor, is a dining-room

(52 by 50 feet with a bay-window 22 by 12 feet) for the majority of the patients, which can be reached from the entrance-hall by means of a door revolving on a central pivot to prevent draughts and to keep the entrance-hall free from the smell of cooking. This room will be supplied with heated carving-tables, so that the food may be kept sufficiently hot. Immediately behind the dining-room, but separated from it by the corridor, is the necessary kitchen and pantry accommodation. Doors will be arranged in this corridor of such a kind that, when meals are being served, a portion of the corridor can be completely shut off from all parts of the house, whilst allowing the passage of servants from the kitchen to the dining-room; at other times the doors will be against the wall, and will allow the free circulation of air from end to end of the corridor. The kitchen is completely cut off from the rest of the building by aerial ventilation, whilst ample provision is made in the way of pantry, bakery, scullery, cold storage, and other accommodation.

The western wing of the administration block consists of an entrance-hall with post and telegraph office, a committee-room, nurses' sitting-room, recreation-room, which may also contain the library of the establishment, and matron's quarters, together with male and female lavatory accommodation for the patients, which is well cut off from the rest of the

building, and conveniently placed near the entrance-hall and dining-room.

We have only arranged for one recreation-room, as we have already pointed out that patients must not be tempted to stay indoors. The Appendix on this subject (No. XV., p. 178) shows that in many sanatoria no common room beyond the dining-room is provided for the patients. At such sanatoria the patients are allowed to sit in the dining-rooms after meals for half an hour or more, and occasional entertainments are given there. The recreation-room we have provided will do away with the necessity of patients ever having to breathe the contaminated air which this practice entails.

The eastern wing contains the sitting-rooms of the medical staff, the secretary's quarters, the dispensary, and the rooms for special forms of treatment, such as the use of the X rays. On the first-floor there is accommodation for servants over the northern part of the central portion, whilst the nurses are provided for in the western wing. The bedrooms of the medical staff, together with a billiard-room, routine laboratory, record-room, and the necessary bathroom and other accommodation, occupy the eastern wing. The stairs are so arranged that the various portions of the first-floor are independent of one another. There will be a small private road leading to this block.

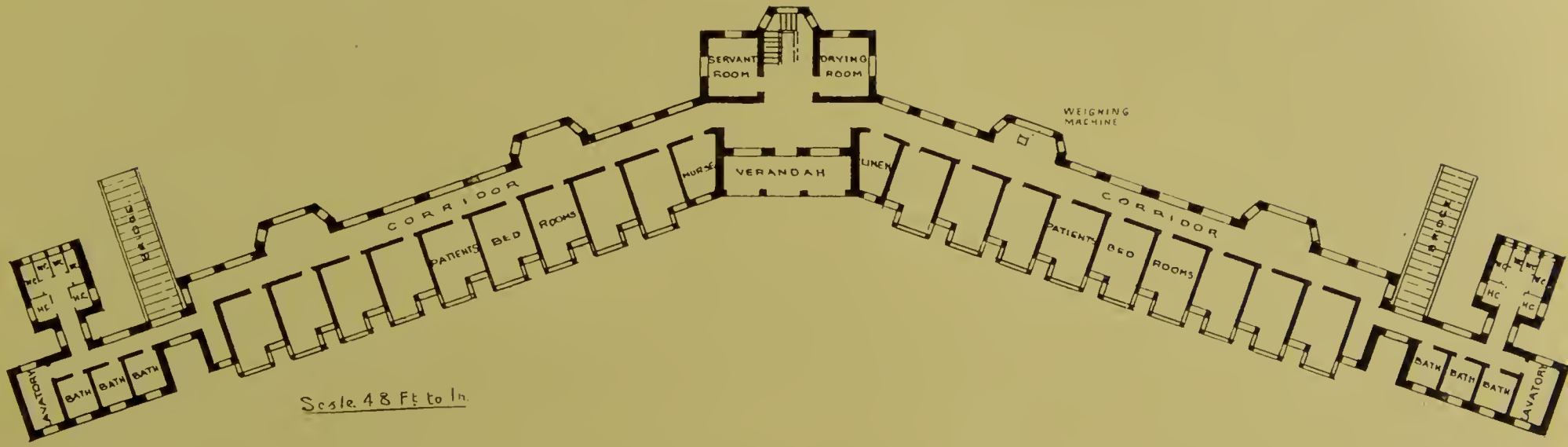


FIG. 10.—BLOCK FOR THIRTY-SIX MALE OR FEMALE PATIENTS. GROUND AND FIRST FLOORS. [*To face p.* 129.

Block for thirty-six male patients.

2. The block for thirty-six male patients (Fig. 10) is two stories high and one room deep. On each floor are eighteen rooms for patients, the aspect of which varies from S.S.E. to S.S.W., as the building consists of two wings joined by means of an open-air gallery (30 by 10 feet) at an angle of 145°. An open-air gallery is not essential in the case of the larger blocks, but it adds to their efficiency, as any of the convalescent patients who suffer a slight relapse, as they not infrequently do, may rest here. It will be entirely open, but provided with rain and sun screens on its southerly aspect, whilst its northern aspect will consist largely of window-space, so that a proper through-draught of air may be readily obtained.

The rooms on the ground-floor, as we have seen, are raised sufficiently above the ground to insure privacy. Behind the patients' rooms runs a corridor 6 feet broad which is amply provided with windows. Each of the latter, as we have already stated, is placed opposite the door of one of the patients' rooms. At either end of the corridor is a window or door which leads directly outside. The upper floor is connected at either end by means of an iron bridge with a path on the sloping elevation immediately behind the house. Bay-windows (16 by 6 feet) project from the northern side of the corridors, so that patients who are confined to their rooms may utilize them in

hot weather or in southerly gales. Accommodation is also provided in the corridor for the weighing of patients. In addition, on either floor and at either end of the wings are the sanitary towers to which we have already referred in detail. Provision is made for cloak or drying rooms where boots may be removed, on both floors, as the bridge on the second-floor allows patients to enter directly from the path at the back. There is an ample supply of store and linen rooms. Electric heaters will be placed on each floor. There is sleeping accommodation for two male servants, and day accommodation for any nurse who may be required. Sufficient space is left in the immediate vicinity of the staircase for a lift, which, however, we do not consider will be necessary. The corridors are so arranged that any portion of the building may readily be isolated in case of need.

Block for thirty-six female patients.

3. The block for thirty-six female patients (Fig. 10, facing p. 129) is in every respect identical with the last, except in so far as sleeping accommodation is found for two female servants.

Block for sixteen patients.

4. The block for patients who for various reasons have to remain in their rooms (Figs. 11 and 12, p. 131) is also almost identical with the larger blocks, save that the dimensions of the open-air gallery are somewhat larger, there is sleeping and day accommodation for two nurses, and a small operating

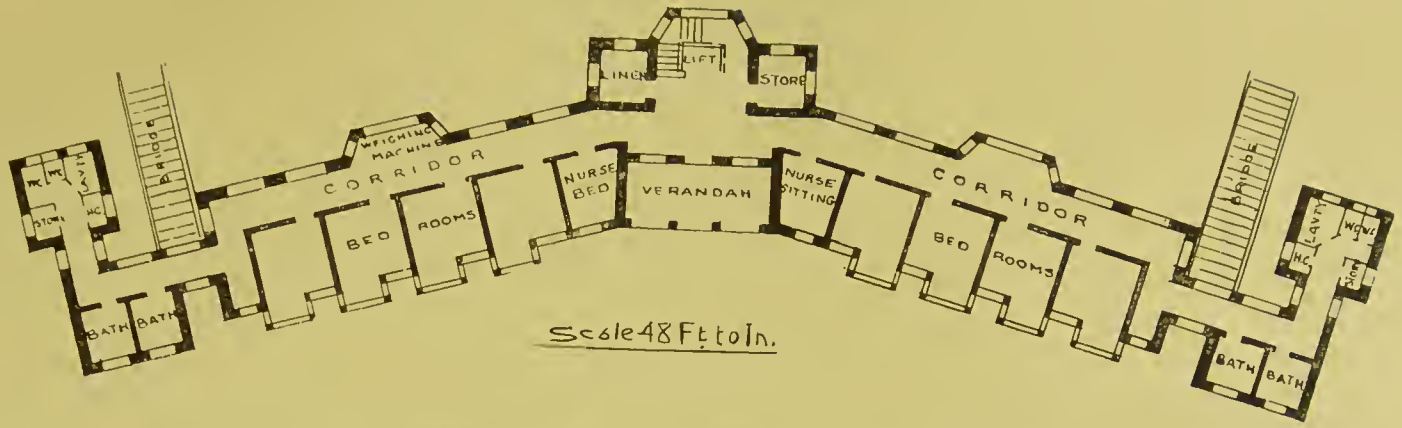


FIG. 11.—BLOCK FOR SIXTEEN PATIENTS CONFINED TO BED. GROUND AND FIRST FLOORS.

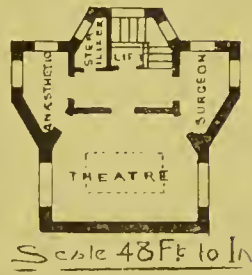


FIG. 12.—OPERATING THEATRE IN BLOCK FOR SIXTEEN PATIENTS CONFINED TO BED.

theatre with its necessary adjuncts is provided. A block of this kind will require an electric lift.

Block for twelve more wealthy patients.

5. The block for patients with more ample means (Figs. 13 and 14, pp. 133 and 134) is also on the same lines. Each patient, however, will have a sitting-room as well as a bedroom, merely in order that when resting on his sofa-chair he may have somewhat more comfortable surroundings. The men and women should have rooms on separate floors. A library and a recreation-room are added. There is separate dining and kitchen accommodation, which is placed at the back, well cut off from the rest of the building, whilst rooms are found for the necessary servants. The accommodation is superior to that of other blocks, and a lift is provided.

Accommodation for visitors.

6. With the exception of two spare bedrooms in the block for patients with more ample means, no rooms are provided for visitors, because we are of the opinion that any visitors who may be permitted to come to the sanatorium from time to time are best housed in neighbouring cottages.

Provision for religious services.

7. No church or chapel will be provided, with the exception of a small mortuary chapel, as we hold that anything which tends to make tuberculous individuals congregate under cover is to be avoided. Services, moreover, may readily be held in the open air.

Block for engine-house, laundry, disinfecting-

8. The block for the engine-house and other accommodation will be placed at a considerable

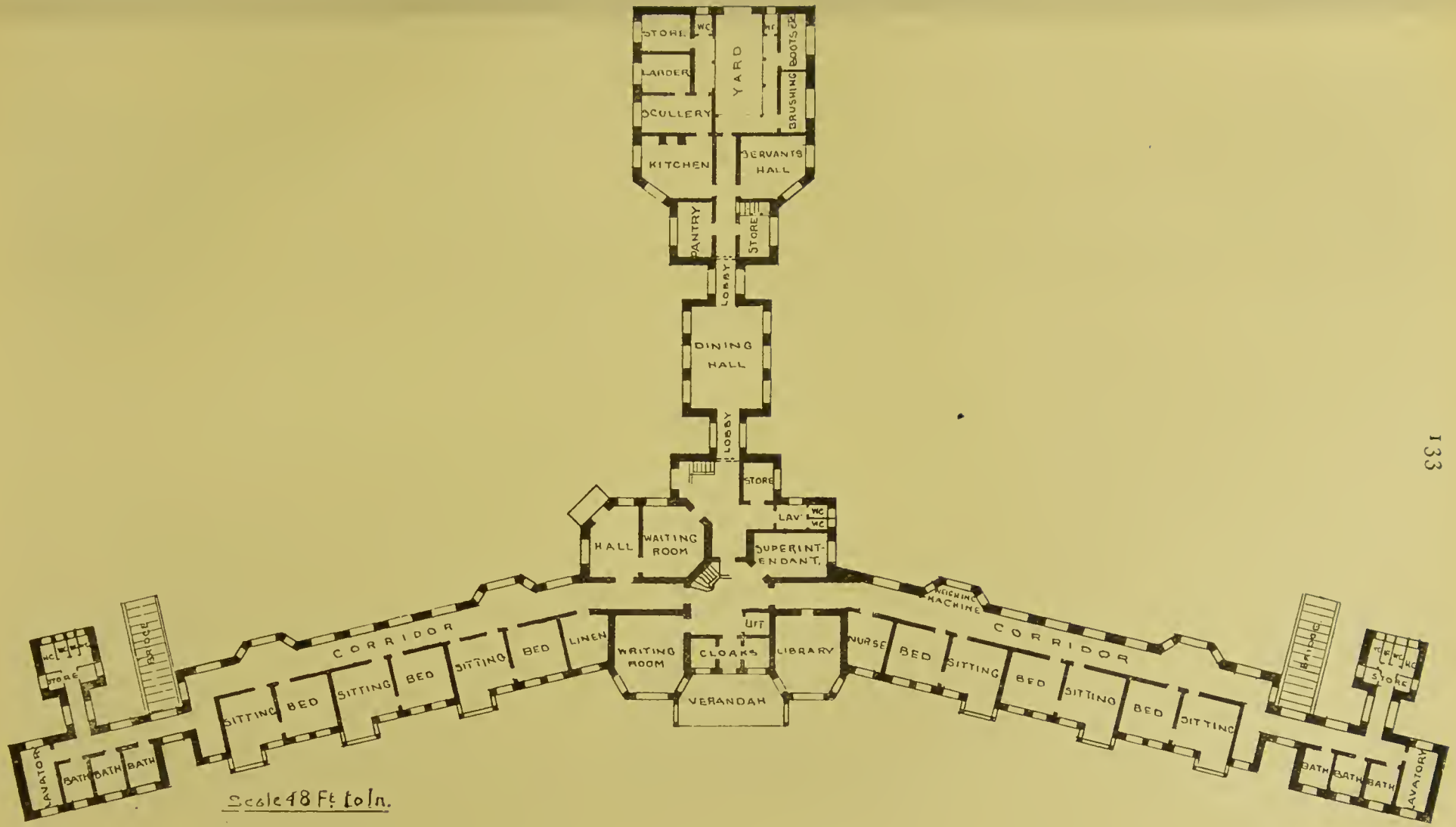


FIG. 13.—BLOCK FOR MORE WEALTHY PATIENTS. GROUND-FLOOR.

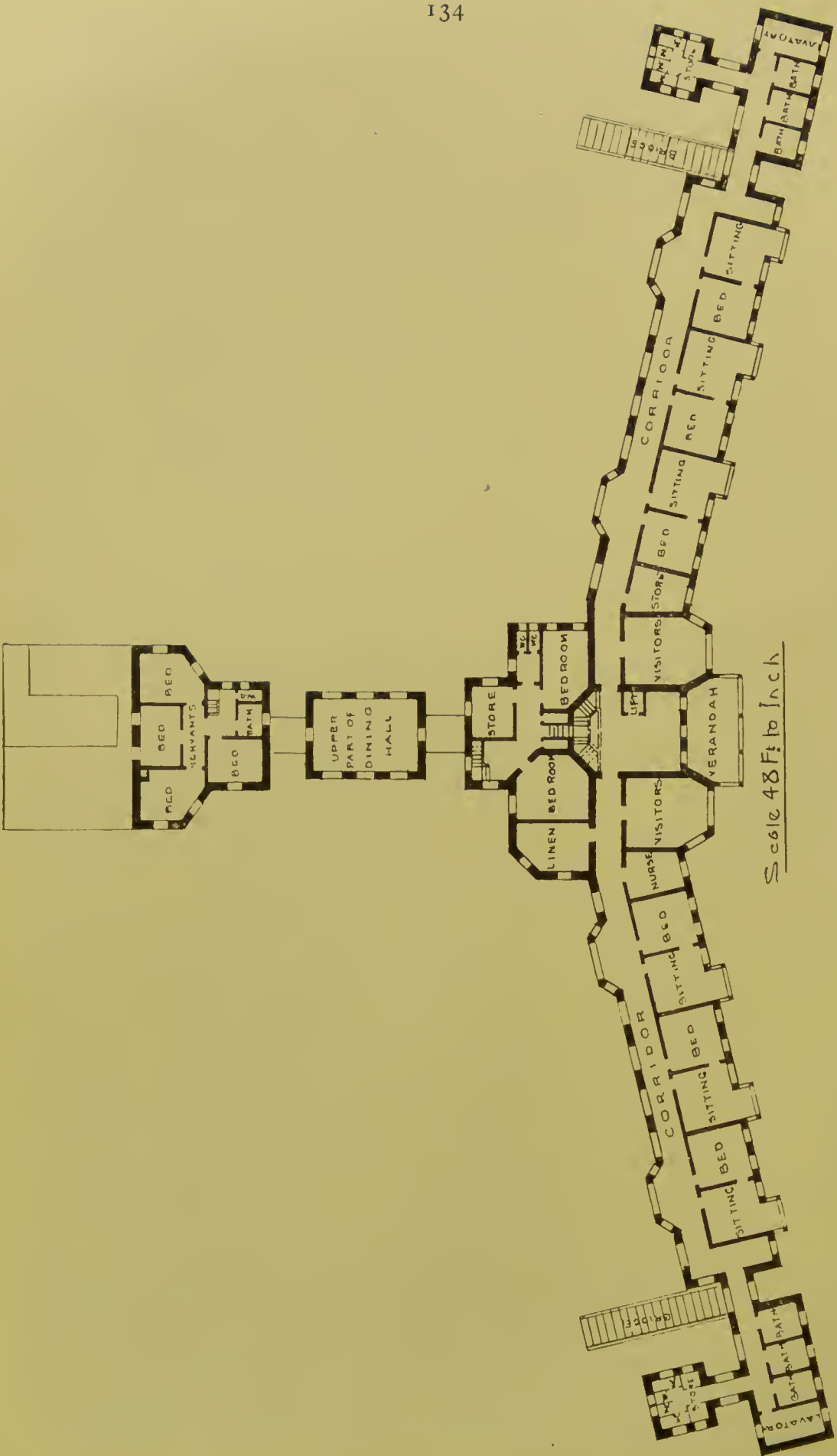


FIG. 14.—BLOCK FOR MORE WEALTHY PATIENTS. FIRST FLOOR.

distance from the patients' rooms and conveniently near a road. The accommodation (see Fig. 7, p. 122) for research and laundry purposes has already been sufficiently described. The disinfecting-station, see Appendix No. XVIII. (*h*), p. 208, consists of two rooms, completely separated from each other by a brick wall into which the disinfector is built so that it communicates with both rooms, one door of the disinfector opening into one room, and its fellow into the other. The infected articles will be brought into one room, and removed when disinfected from the other side of the disinfector and dealt with as may be necessary. No communication save by telephone exists between the two rooms, the walls and floors of which are of cement. The mortuary is so placed that it may readily be reached by a hearse without notice being attracted, and the post-mortem room is in connection with the laboratories. A dust-destructor and an ice-house are also provided in this building.

station and research laboratories, together with a mortuary and post-mortem room.

The engine-house, with accommodation for an engineer and his wife, will form part of this block, but will be so placed that no vibration will be communicated to the laboratories.

An Alternative Plan.

This is added (Figs. 15, 16, and 17, facing p. 136) in case either the character of the site or the amount

of money at disposal prevents the adoption of the separate-block system. It consists of a central portion and two long wings. The general arrangement is the same as in the separate-block scheme. The central portion consists of a recreation-room and the quarters for the medical staff, together with dining-room and kitchen accommodation in a northern annexe. The eastern wing consists of two floors, and contains rooms for forty-four female patients, together with open-air galleries, sanitary towers, and nursing and other rooms. The western wing in a similar way provides for forty-four male patients. An operating theatre is placed on the second-floor of the central portion. The patients with more ample means will have a separate house, as in the other scheme, whilst no change is made with regard to the engine and laundry block.

Means of Communication.

The separate blocks and the power-house should be amply supplied with telephonic communication to the administration block and to the quarters of the medical staff. Each patient's room should be provided with an electric bell which rings into the corridor during the day, and into a nurse's bedroom at night, or, if there is no nurse in the block, into a servant's room, so that a nurse may be summoned if necessary.

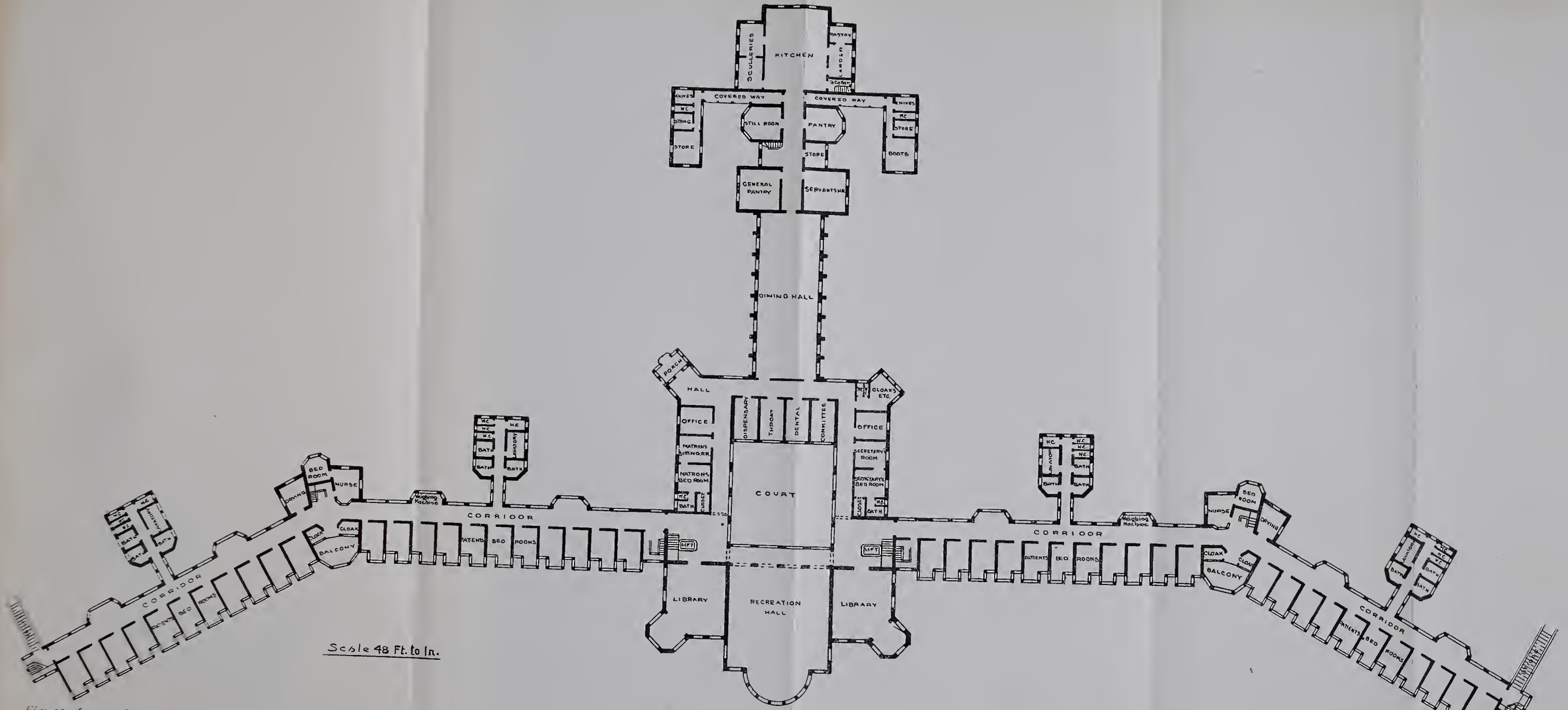


FIG. 15.—ALTERNATIVE PLAN BLOCK FOR EIGHTY-EIGHT PATIENTS. GROUND-FLOOR.

Figs. 15, 16, 17, to face p. 136.]

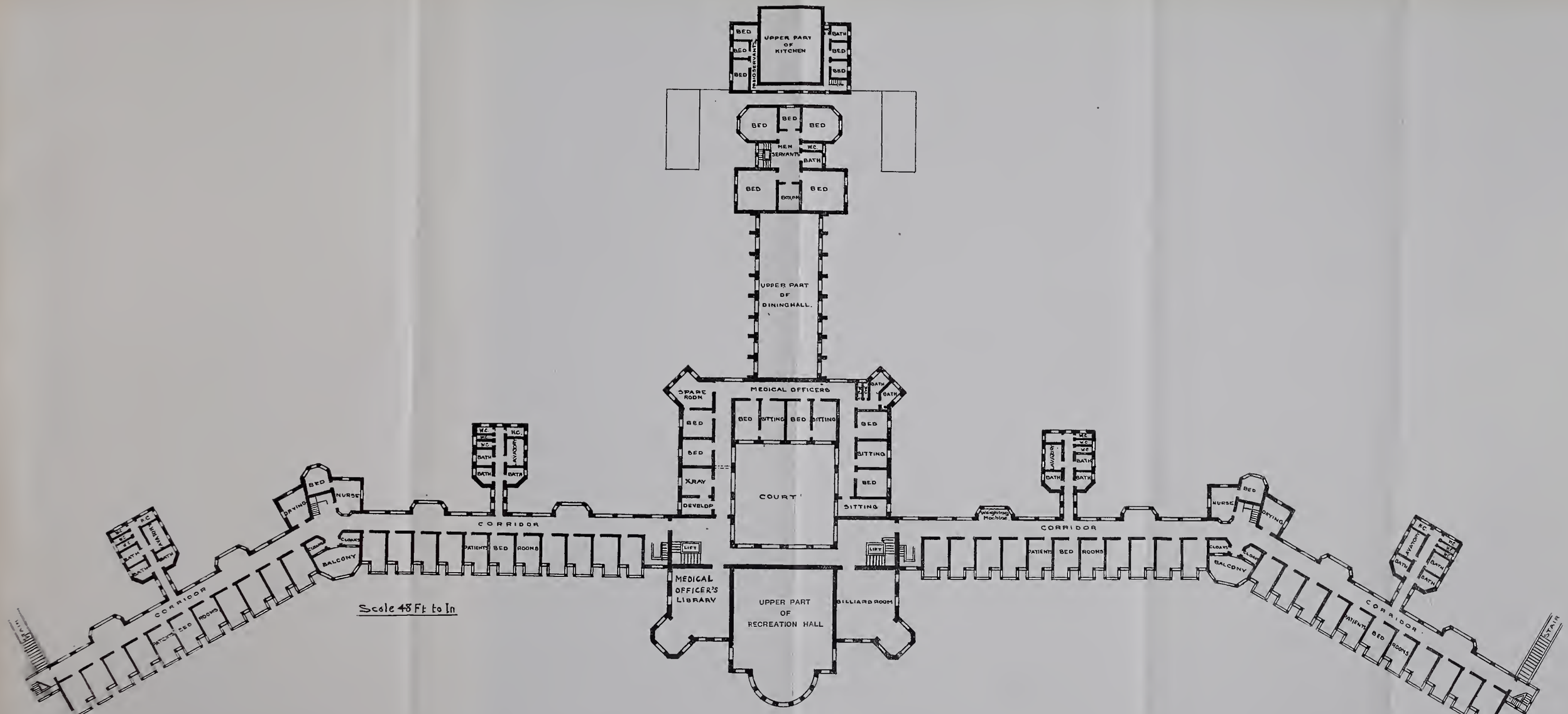


FIG. 16.—ALTERNATIVE PLAN BLOCK FOR EIGHTY-EIGHT PATIENTS. FIRST-FLOOR.

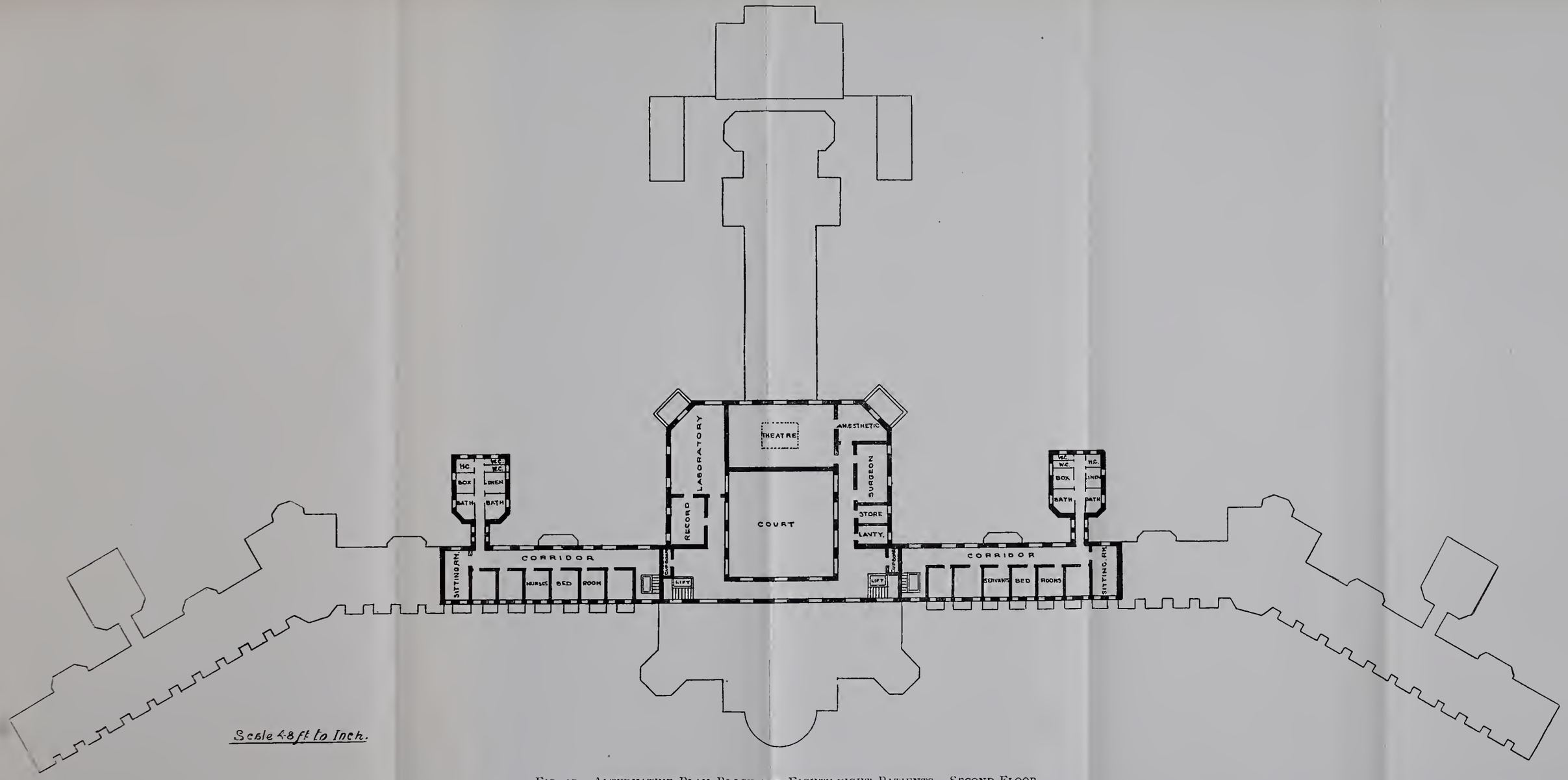


FIG. 17.—ALTERNATIVE PLAN BLOCK FOR EIGHTY-EIGHT PATIENTS. SECOND-FLOOR.

The Laying-out of the Grounds and the Provision of Shelters.

This, naturally, must entirely depend upon the character of the available land. No better guide exists than the magnificent grounds attached to Brehmer's original sanatorium at Görbersdorf. Walks of varying gradients must be provided—some on the level ground in the immediate neighbourhood of the buildings for patients who are restricted to this form of exercise; other of gradients varying from 1 in 300 to 1 in 60 for the more convalescent cases. These paths must be carefully prepared, so that they readily absorb moisture and rapidly dry after rain. This is best done by laying them down with rubble or ash (not cinder) under a covering of gravel. The walks must be varied, so that shelter may be obtained whatever the direction of the wind. Some paths must be laid through the woods, which give shelter from rain, sun, and wind; other must be in the open. Care must be taken, as far as possible, to prevent any path overlooking the patients' bedrooms, whilst no path for the use of the patients should lead downwards away from the buildings towards the valley, as it is important that patients in returning from their walk should do so downhill, and so avoid any over-exertion. The gradients of the various paths at certain sanatoria are marked

Paths.

on the trees by coloured bands, but there is no occasion for this, as the character of each patient's walk should be entirely under the direction of the physician.

Seats. In the grounds of Brehmer's sanatorium seats are provided every twenty paces, so as to allow any patient to stop and to rest the moment he feels that there is any necessity to do so. Whilst it is true that many seats must be provided, and that these should be so arranged that advantage is taken of the view, a seat at every twenty paces seems unnecessary. At Nordrach the difficulty is overcome by each patient carrying a small square of thick rubber, as in this way the patients can select their own resting-place and avoid sitting in the immediate proximity of their fellow-patients. Individual seats may be named, so that patients may know the particular walk they have to take. Trees, preferably evergreens, should be arranged near the house in such a way that they give shelter against wind for the more feeble patients. At the same time the free ingress of air and sunlight must not be prevented.

Shelters. Shelters of various descriptions, in addition to the covered way already described, must be placed in the grounds, not only near the houses for the use of feeble individuals, but at more distant points. They are necessary for protection against wind, excessive sun, and rain ; they should be as simple in construc-

tion as possible, capable of being readily disinfected, and cleaned like all other furniture in the establishment, and so placed as to allow a free circulation of air and to take advantage of the natural beauties of the country. Fig. 18 shows a simple form. It is best that many of them should be made to turn on a pivot, as in this way shelter from any wind is readily obtainable; in cases where the natural configuration

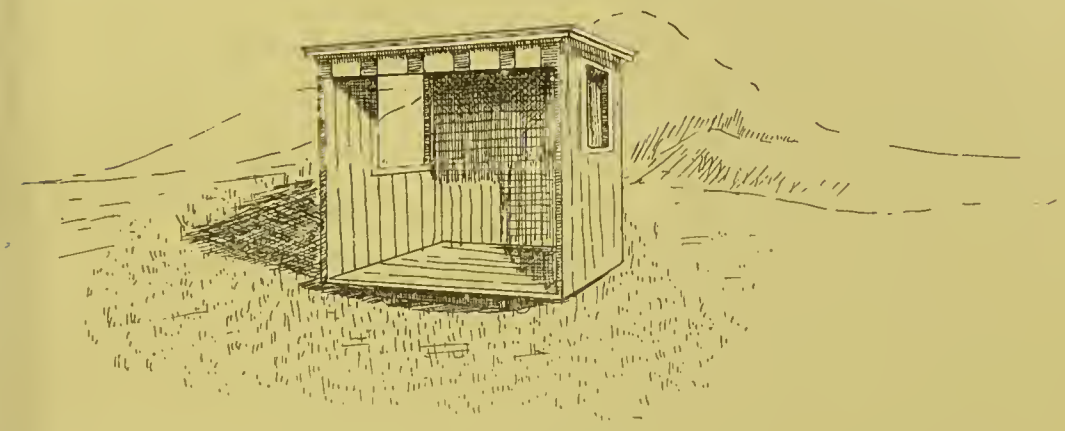


FIG. 18.—SHELTER.

of the grounds affords sufficient shelter, fixed huts may be used. It is an advantage that some of the shelters should be fitted with electric light. Leriche advocates the establishment of a *cordon sanitaire* round the grounds, but there is no reason why convalescent patients should be confined to the private grounds of the sanatorium, unless these are very large, provided that they do not go near places where there is much dust or human traffic. In addition, provision must be made for the necessary supply of vegetables,

with some flowers and plants for the larger rooms, and the grounds should be laid out in as attractive a manner as the money at disposal allows.

A Covered Way between the Various Buildings.

When a sanatorium is built on the separate-block system, it is as well, at any rate in England, to have a covered way from house to house, so that the patients may avoid unnecessary exposure on their way to and from the dining-room. As may be seen from Fig. 1, p. 73, we have provided a covered passage between the buildings, which we have arranged in the form of a crescent. The block for the female patients is joined on the one side with the administration block, and on the other with the sick-house, whilst the block for male patients is joined with the administration block and with the house set apart for the more wealthy patients. In this manner the medical staff may visit all the houses without being exposed to inclement weather, whilst the fact that the blocks for the more wealthy patients and for the more severe cases respectively, are placed at either end of the crescent, will prevent any great traffic through the corridors of the houses for thirty-six male and female patients. The covered passage, Fig. 19, p. 141, will be freely open in the immediate neighbourhood of the individual houses, so that it

FIG. 19.—COVERED WAY.

cannot ventilate into them. Elsewhere it will be provided with glazed screens at intervals, which will give shelter to those sitting on the seats provided on the outer aspect of each side. The arrangement of these seats should be of great service, as by means of them patients who are unable to go into the woods will readily obtain protection from any wind.

The Cost of the Proposed Scheme.

It is impossible to give any definite statement as to the cost of the proposed scheme without knowing the cost of labour and of materials at the chosen site and other details. Many sanatoria, have been built for the poor at a cost of from £250 to £300 a bed, but modern sanatoria, which contain single-bedded rooms and are constructed with a view to comfort, are more expensive. Thus, the Hohenhonnef, which consists of one large block and accommodates 109 patients, cost £660 a bed ; the Anstalt, at Nordrach Colonie, for twenty-four patients, which is usually held up as an example of cheapness, cost £500 per bed ; the projected sanatorium at Manchester (100 patients) is expected to cost £1,000 per bed ; and the projected Brompton Sanatorium at Frimley, for 100 beds in one large block, is to cost £56,000 ; whilst the most recent fever hospitals in England, hospitals which have as many as twenty patients in a ward, cost from £500 to £550 a patient.

APPENDICES

APPENDIX I

Consisting of a Summary of the Main Features of the Scheme

It has been decided, from various considerations detailed in the text, to build the sanatorium on the separate-block system (see Fig. 1, p. 73). The building will be arranged, if the site permits, in the form of a crescent, and will comprise—

1. Administration block, with dining and other accommodation.
2. Block for thirty-six more or less convalescent male patients.
3. Block for thirty-six more or less convalescent female patients.
4. Block for sixteen patients who, for various reasons, are confined to their own rooms for the greater part of the day.
5. Block for twelve patients with more ample means.
6. Block for engine-house, laundry, disinfecting-station and research laboratories, together with a mortuary, post-mortem room, and other accommodation.

GENERAL DETAILS OF CONSTRUCTION.

The outside of the buildings will be made as attractive as possible. In the patients' blocks the rooms are placed on one side of a corridor which has windows on the opposite side. All buildings for the patients, together with the administration block, are two stories high. Precautions are taken against the conduction of noise and the possibility of fire. Adequate measures are taken to make the buildings dry and to insure the privacy of the rooms. The buildings will be of concrete and steel girders, the partitions being made of cement. All angles will be rounded off, and no mouldings or projecting architraves will be used. The floors of the rooms will be of teak, the walls being lined in such a way that they can be readily cleaned. The ceilings will be lined with mezzotile. The stairs will be of teak. All windows will be casements with fanlights carried flush to the ceiling, and specially fitted so as not to afford any lodgment for dust. All glass will be plate. All buildings are so arranged that any portion may be readily isolated in case of need.

1. *Administration Block* (Figs. 8 and 9, pp. 124 and 125).—This is placed on a *slightly* higher level than the other buildings, and will have a small private road leading to it. The main aspect is southerly. In this block are placed the kitchen and dining accommodation for the greater number of patients, male and female lavatory accommodation, post and telegraph office, quarters for the medical staff, with laboratory for routine examination and rooms for special departments (such as X-ray, dental, and throat rooms), nurses' and servants' quarters, accommodation for secretary and matron. Special arrangements are made so that the kitchen and dining-room may not ventilate into other portions of this

block, whilst the part used by the patients is entirely cut off from the rest of the building. For reasons given in the text, only one recreation-room is provided. This can also serve the purpose of a library.

2. *Block for Thirty-six more or less Convalescent Male Patients* (Fig. 10, facing p. 129).—This is two stories high, and contains eighteen rooms on each floor for patients. The aspect of these rooms varies from south-south-east to south-south-west, the building consisting of two wings, as in the accompanying plan (Fig. 20), placed at an angle of 145°. The rooms on the ground-floor are raised

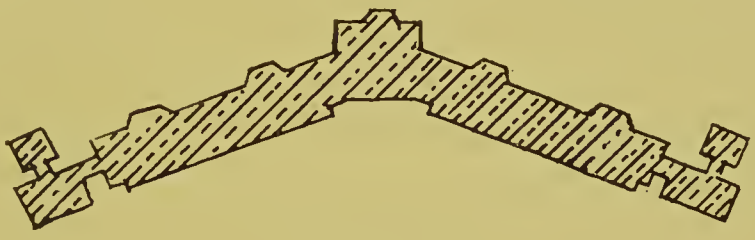


FIG. 20.

sufficiently above the ground to insure privacy. Behind the patients' rooms runs a corridor 6 feet broad, which is amply provided with windows, one of which is placed opposite the door of each of the patients' rooms, and is covered with cork carpet to lessen the noise of the necessary traffic. At either end of the corridor is a window or a door which leads directly on to the open, and so permits of the free circulation of air. The upper floor is connected at either end by means of a bridge with a path on the sloping elevation immediately behind the house. In the corridors bay-windows (16 by 6 feet) project so that patients who are confined to their rooms may utilize them in hot weather or in southerly gales. In addition, on either floor and at either end of the wings are sanitary towers, which are completely cut off from the patients'

rooms by aerial cross-ventilation, and contain lavatory, baths, water-closet, and housemaid's sink accommodation. Provision is also made for cloak-rooms, linen and store rooms, day-nurses' accommodation, and for two male servants' sleeping accommodation. On either floor in the centre of the building is a small open-air gallery, with a southerly aspect, for the use of any of the patients housed here who may suffer a relapse. The open-air galleries are not essential in the case of the larger blocks, but in our opinion add to their efficiency, whilst the exact position of the sanitary towers in these blocks must be determined by certain considerations mentioned in the text.

3. *Block for Thirty-six Women* (see Fig. 10, facing p. 129). —This is in nearly every respect identical with the last, save that quarters are found for two female servants instead of the male servants.

4. *Block for Sixteen Patients who are more or less confined to their Rooms* (see Figs. 11 and 12, p. 131).—This is also almost identical with the larger blocks, save that the open-air gallery is somewhat larger, and that there is day and night accommodation for two nurses, together with a small operating theatre and its necessary adjuncts. This block will have a lift.

5. *Block for Twelve Well-to-do Patients* (see Figs. 13 and 14, pp. 133 and 134).—This is on the same lines. Each patient will, however, have a sitting-room as well as a bedroom. These sitting-rooms will be used only when the patient is resting on a sofa-chair. Two recreation-rooms for occasional use are added on the same lines as those in the administration block. The accommodation is superior to that of the other blocks, and a lift is provided. Separate kitchen and dining accommodation is found for these patients, but this is well cut off from the bedrooms, and is placed behind the building, as may be seen from

the accompanying plan (Fig. 21). A superintendent and a separate staff of servants will be attached to this block.

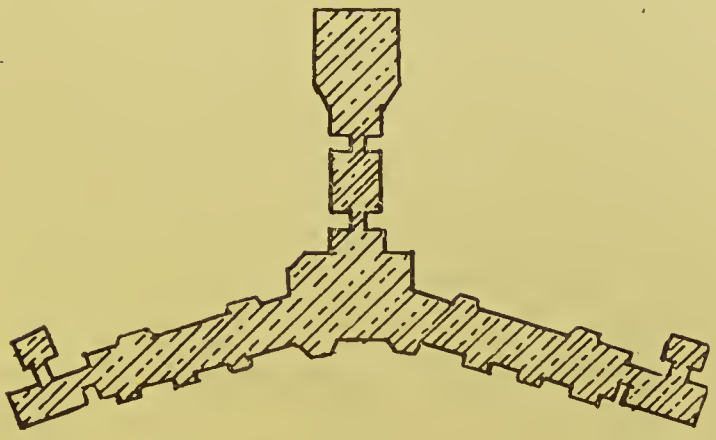
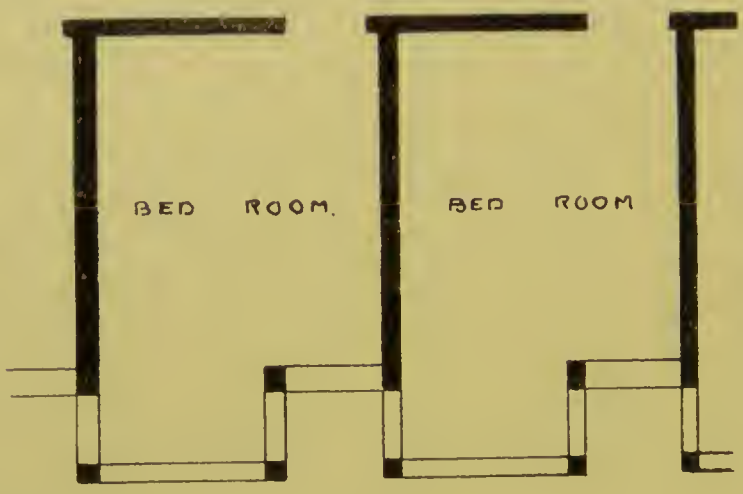


FIG. 21.

6. *Block for Engine-house, Laundry, Disinfecting-station, and Research Laboratories, together with a Post-mortem Room, Mortuary, and other Accommodation* (see Fig. 7, p. 122).—The laundry and disinfecting-station are of the most modern type and communicate with one another. Ample provision is made for the elucidation of bacteriological, pathological, chemical, and other problems in connection with tuberculosis. A post-mortem room is in connection with the laboratories, and a mortuary is conveniently placed near the road. The engine-house is placed in the same block, but in such a position that no vibration will be communicated to the laboratories. It will contain the necessary electrical plant, together with accommodation for an engineer and his wife.

Each room for an individual patient (see Figs. 2 and 3, pp. 89 and 90) is 10 feet high, 12 feet broad, and 14 feet deep. The way in which the walls are to be lined depends upon the amount of money available, but we propose that they should be lined with artistic glazed tiling to the height of 3 feet 6 inches, and then oil-painted. In the

case of the rooms for the more wealthy patients washable paper will be employed. The floor will be of teak. Precautions are taken to prevent the head of the bed coming within 1 foot of the wall. The door is to be sufficiently wide (3 feet 6 inches) to allow a bed to be wheeled through, and is placed opposite a window in the corridor. Above the door, and throughout the upper part of the northern wall, are fanlights 2 feet deep. The south side consists chiefly of window space; there is a rectangular projection at the eastern (or the western, as the case may be) half of



Scale 1 foot to $\frac{3}{32}$ inch. FIG. 22.

this aspect of the room, 7 feet wide, 4 feet deep, and 10 feet high. This projection is so arranged, as may be seen from the accompanying plan (Fig. 22), that it has a window looking south, and smaller ones looking east and west. We object, for reasons given in the text, to the use of verandas or galleries where many patients can assemble, and our aim is to afford each patient, by means of these projections, a place in which to rest upon his sofa-chair under such conditions, that, whatever the state of the weather, he may always be able to open one or more windows, and so enjoy the necessary free circulation of

air. We regard these projections as most useful, but we have arranged the buildings in such a way that they can be dispensed with, without affecting the general scheme, if there is not sufficient money available for their erection. On the western (or eastern, as the case may be) half of the southern aspect is a window 3 feet 6 inches wide. Above these casement windows in all cases are fanlights, the top of which is flush with the ceiling. The casement windows commence 2 feet 6 inches from the floor. Each room will have a special piece of furniture, open at the back so that it may be thoroughly cleaned, and comprising wardrobe with sloping roof, drawers, looking-glass and washhand-stand, in addition to the ordinary furniture. Light perforated blinds are provided for protection against sun and rain.

With the exception of two spare bedrooms in the block for patients with more ample means, no rooms are provided for *visitors*, because we are of opinion that any visitors who may be permitted to come to the sanatorium from time to time are best housed in neighbouring cottages. No *church or chapel* will be provided, as we hold that anything which tends to make tuberculous individuals congregate under cover is to be avoided. Services, moreover, may readily be held in the open air. The *lighting* will be by means of electricity. The *ventilation* will be almost entirely by means of open windows. In addition, each patient's room is provided with an electric fan for use in still and hot weather, together with a small shaft with mica flap to prevent down-draught. The larger rooms, such as the dining-rooms, and other parts of the building, such as the kitchen, water-closets, and the like, are amply provided with electric extractor fans.

All heating and cooking will be carried out by means of electricity, with the exception of the heating required for

warming water for baths, for laundry purposes, or for the steam-disinfector. This latter will be provided, for economical reasons, by means of upright boilers worked by coke and supplied with efficient smoke-destructors. The electricity will be generated by means of water-power, gas, or oil, according to the possibilities of the site ; in this way the use of coal and coke, which we show in the text is most injurious, is as far as possible avoided (see Appendix No. XVII. (*b*), p. 185, for specification).

The *drainage* will be directed, if possible, into ordinary sewers (see Appendix No. XIX., p. 208, for specification), but failing this into a large impervious tank, the contents of which will be dealt with on the biological system of Cameron. The *slop water* will be disposed of by means of Kenwood's system of sub-irrigation.

The methods adopted to prevent the *spread of infection* and for the destruction of tubercle bacilli will be as follows :

(*a*) The sputum will be collected in pocket flasks and in the patients' rooms by suitable papier-maché cups. These cups and their contents, together with the contents of the flasks, will be mixed with sawdust and burnt in special small incinerators in each block. The flasks will be thoroughly disinfected in the same rooms, being placed in water to which sodium bicarbonate has been added and then gradually raised to 102° C., and kept at this temperature for half an hour. Handkerchiefs will be of some cheap material and burnt after use, but the well-to-do patients may have ordinary handkerchiefs, which will be disinfected in the steam disinfecting-station.

(*b*) The floors, the tiled portion of the walls, and the furniture, will be kept clean by means of moist cloths dipped in a 1 per cent. solution of chlorinated lime. The walls will be periodically well scrubbed with soap and water. When a patient leaves, the walls of his room will be disinfected by formaldehyde vapour, generated by a Trillat's autoclave.

(*c*) Linen, coverings to cushions, ordinary clothes, small mats, wicker chairs, mattresses, and the like, will be collected in suitable receptacles and treated in the steam disinfecting-station.

(*d*) Articles which cannot be sterilized by steam, such as books and combs, will be disinfected by formaldehyde, generated by a Trillat's autoclave in a special chamber.

(*e*) Crockery and knives and forks will be treated in ordinary surgical sterilizers.

(*f*) Old articles, dust, and refuse will be dealt with in a special dust-destructor attached to the engine-house.

FACILITIES FOR OBSERVATION AND RESEARCH.

1. *Observation.*—X-ray, dental, and throat rooms with test laboratory and record-room are provided in the administration building.

2. *Research.* — Two laboratories for bacteriological, pathological, chemical, and physiological work, research-rooms, an animal house, and a post-mortem room, etc., are placed in the laundry block. Facilities for meteorological observations are also provided.

THE GROUNDS

will be carefully laid out with paths on the flat and of varying gradients. These paths will be of such a nature that they dry readily after rain. *Shelters*, some of them on pivots, are provided (see Fig. 18, p. 139). The grounds and some of the shelters will be efficiently lighted with electricity. The various buildings are connected with the administration block by a *covered passage* (see Fig. 19, p. 141). This in the immediate vicinity of the buildings is open, but elsewhere a central glazed screen, placed at intervals, will give shelter from the wind. On the outer portion of this covered way on either side are seats at short intervals, which are protected by the overhanging roof. By this means patients who are unable

to go into the woods will readily obtain protection from any wind. The various blocks are so placed with regard to this passage that there is a minimum of traffic through the corridors. There is ample *telephonic communication* between the various buildings and the quarters of the medical men and elsewhere, together with a complete installation of electric bells.

AN ALTERNATIVE PLAN

for eighty-eight patients, embodying similar ideas and principles (see Figs. 15, 16, 17, facing p. 136), but consisting of one large single building, is appended, in view of the facts that it is impossible to come to any definite decision as to the character of the building without complete knowledge of the configuration of the proposed site and of the amount of money which may be commanded.

APPENDIX II

Showing the Statistical Results of Treatment in Forty-four Open-air Sanatoria

(*a*) In twenty-three establishments for paying patients.
(*b*) In sixteen establishments for the poor.
(*c*) In five establishments for children.

The statistical results of the open-air treatment of tuberculosis are useful, but are open to the objection that at present they are not all calculated in the same manner. Thus, the medical men at some sanatoria regard a case as being permanently arrested on slighter evidence than others; some, again, take the absence of physical signs or of bacilli in the sputum as a test; whilst others are only content with more or less complete restoration of the working capacity. It will be seen that the following statistics are not always strictly comparable; they, however, show the general limitations of this form of treatment.

(*a*) *Twenty-three Sanatoria for Paying Patients.*

Name of Sanatorium.	Stage A = Comparatively Early; B = Advanced.	Percentage of Cases in which there was *Apparent Arrest of the Disease.*	Total Percentage of Cases in which there was *Real Improvement.*	Authority.
Brehmer	A and B	26·6	75 to 80	Manasse. Achtermann.
	A	58·0	89	Kobert.
Nordrach Colonie	A and B	30	95	Knopf.
Hygeia	A and B	22·5	68·7	A. C. Klebs.
Falkenstein ...	A	28	73	Dettweiler and Hess.
Reiboldsgrün ...	A	41·6	70·2	Driver.
Canigou	A	55	65	Giresse.
	B	6	31	
Hohenhonnef ...	A	43·4	69	Meissen.
Leysin	A and B	12·7	72·2	Burnier.
	A	53·3	86·6	
Winyah	A	81	100	von Ruck.
	A and B	22·6	65	
Davos Turban ...	A	50	90	Turban.
Muskoka Cottage	A	41	74	Elliott.
Römpler's ...	A and B	27	77	Römpler.
Sharon	A and B	25	—	Bowditch.
Haufe's St. Blasien	A and B	17	84	Sander.
Montana	A	10	50	Stephani.
	B	2	10	
De Trespoey ...	A and B	22	55	Crouzet.
Laurentian ...	A	46	62	Riched.
	B	18	40	
Nordrach on Mendip ...	A	45	82	Rowland Thurnam.
Moorcote... ...	A	85	100	Baker.
	B	10	60	
Crooksbury ...	A	45	87	R. Walters.
	B	0	45	
Rudgwick ...	A and B	31·5	89·5	McCall.
Nordrach in Wales	A and B	77·2	84·2	Morton Wilson.
Rossclare ...	A	20	95	Crosby Walch.

(*b*) *Sixteen Sanatoria for the Poor.*

Name of Sanatorium.	Price per Week.	Stage A = Comparatively Early. B = Advanced.	Percentage of Cases in which there was *Apparent Arrest of the Disease.*	Total Percentage of Cases in which there was *Real Improvement.*	Authority.
Grabowsee ...	£1 or less	A and B	14·1	78·5	Ellerhorst.
Halila ...	£1 or over	A and B	27·0	70·7	Gabrilowitch.
Davos (Basel)	About £1	A	67·7	90·8	Kundig.
Adirondack ...	£1	A	57·11	77·1	Trudeau.
Loslau ...	£1	A and B	11·0	89·0	Schrader.
Oderberg and Glückauf ..	Nil	A and B	4·0	77·0	Ott.
Montefiore Home ...	Nil	A and B	10·6	40·4	Herbert.
Braunwald ...	18s.	A	39·0	99·6	Fischer.
		B	11·0	90·0	
Reknaes ...	10s.	A	39·0	91·0	Kaurin.
		B	1·8	68·8	
Sanatoria of Scotland ...	—	A	19·0	90·0	Hyslop Thomson.
Belzig ...	Nil	A and B	17·2	82·8	Moeller.
Hauteville ...	15s.	—	45·0	88·0	Dumarest.
Loomis ...	£2	A	25·0	75·0	Stubbert.
Chestnut Hill	—	—	8·0	19·5	Cohen and Bacon.
Ventnor ...	10s.	A	16·4	81·8	Coghill.
Ruppertshain	18s. or over.	A	30·0	70·0	Nahn.

(*c*) *Five Sanatoria for Children.*

Name of Sanatorium.	Stage A = Comparatively Early; B = Advanced.	Percentage of Cases in which there was *Apparent Arrest of the Disease*,	Total Percentage of Cases in which there was *Real Improvement.*	Authority.
Ormesson... ...	A	34·0	64·0	Jaoul.
Villiers	A	25·5	69·9	Vagnier.
Forges les Bains...	A	50·0	75·0	Dumenge.
Arcachon... ...	A	21·7	67·6	Lalesque.
Refsnaes	A	25·0	67·4	Shepelern.

In addition to the above, many sanatoria, such as Malchow, Schömberg, Grabowsee, Rehburg, etc., give statistics under the headings of 'greatly improved' and 'improved.' The percentage under either heading is about 40 to 50 in the early stages. Solly states that, taking all non-Alpine sanatoria together, the percentage of improvement in early stages is 95, in later stages 58, whereas in the case of patients who are not treated in sanatoria the percentages respectively are 71 and 28 in lowland climates and 89 and 63 in highland climates.

APPENDIX III

Showing whether Better Results are obtained at any Particuar Season of the Year at Fifty Sanatoria

	No. of Sanatoria.	Names of Sanatoria.
I. Definite statement that no different results are obtained at any particular season	21	Moorcote, Nordrach Colonie, Cotswold, Montefiore Home, Hohenhonnef, Ruppertshain, San. des Pins, Hauteville, Oderberg, Falkenstein, Braunwald, Reknaes, Rossclare, Nordrach on Mendip, Linford, Canigou, Beauregard, Montana, Glückauf, Rostrevor, Brehmer.
II. No noticeable difference observed	11	Luitpoldheim, Boserup, Chico Springs, Reiboldsgrün, Waldhof-Elgershausen, Friedrichsheim, Consumption Sanatoria of Scotland, Belzig, Vale of Clwyd, Davos German, Davos Dorf.
III. Best results in winter	18	Loomis, Durham, Rudgwick, Sülzhayn, Zarskoje, Halila, Dunstone Park, Grampian, Crooksbury, Holne Chase, Nordrach on Dee, Nordrach in Wales, Adirondack, East Anglian (October, November, December), National Hospital for Consumption in Ireland, Loslau, Laurentian, Montefiore Home.

APPENDIX IV

Showing the Class of Cases refused by Forty-eight Sanatoria

(*a*) *Sixteen Sanatoria which refuse only those Patients who are in a Moribund Condition.*—Nordrach Colonie (discourages diabetes), Rudgwick, Cotswold, Montefiore Home, Friedrichsheim, Hohenhonnef, Rossclare, Zarskoje Selo, Dunstone Park, Grampian, Holne Chase, Vale of Clwyd, Nordrach in Wales, Linford, Guimar, Rostrevor.

(*b*) *Twenty-four Sanatoria which only refuse Advanced Cases.*—Loslau, Waldhof-Elgershausen, Falkenstein, Reiboldsgrün, Moorcote, Chico Springs, Luitpoldheim, Rupertshain, Halila, Braunwald, Sülzhayn, Reknaes, Consumption Sanatoria of Scotland, Belzig, Nordrach on Dee, Hauteville, Whitehaven, Laurentian, Nordrach on Mendip, Loomis, Davos Dorf, Durham, Canigou, S. des Pins.

Others refuse cases in which there is excavation (Adirondack), laryngitis (Trespoey), cardiac or asthmatic affections (Montana), chronic alcoholism (East Anglian), and the like. Others, such as Crooksbury, refuse patients who (*a*) are moribund, (*b*) have both bases affected, (*c*) active laryngeal tuberculosis, or (*d*) a temperature over 103° F. A certain number refuse all save those in a very early stage of the disease.

APPENDIX V

Showing the Conditions which determine whether Patients should be kept in Bed or allowed to take Exercise

Compiled from answers given by the medical men at fifty-two sanatoria to the questions :

(*a*) *Under what circumstances do you prescribe rest ?*

(*b*) *What form of exercise do you prescribe ?*

Sanatorium.	Answer.
Nordrach Colonie	The questions require a volume, and can only be determined on individual considerations. Some patients with a temperature of more than 97·8° F. a.m., and more than 100° F. p.m., taken in the rectum, must rest in bed all day, and must not leave the bed before the temperature has been below these levels for a week. This, however, must not be taken as being anything like an absolute rule.
Brehmer	Uphill exercise whenever the patient's condition permits.
Moorcote	Rest in bed for a day or two on arrival, then rest in the open for a day or two whatever the stage of disease; rest in bed in cases of hæmorrhage, pleurisy, or rapid softening, and when the temperature is above 98·4° F. in the morning, or 100·4° F. in the evening. The last rule is modified in certain cases. Walking, gradually increasing the distance, 50 yards to 5 miles twice daily, unless exercise raises the temperature or pulse-rate, or causes much exhaustion or dyspnœa.

Sanatorium.	Answer.
Dr. Römpler's, Görbersdorf	Before dinner and after meals exercise is forbidden. Febrile and dyspeptic patients rest on couches in open air. Slightly febrile patients may take drives.
Boserup	Promenading when temperature under 37·7° C.
Rudgwick... ...	Occasionally a day in bed or rest in the open. Slow walking (two miles per hour), deep breathing exercises, and light gymnastics if temperature is normal.
Chico Springs ...	Rest for high fever or hæmorrhage. All sorts of exercise when no fever exists and when these do not cause fever.
Luitpoldheim ...	Bed only with fever above 38° C.; otherwise rest six and a half hours daily.
Montefiore Home	Some cases get the rest cure, such as asthenia, hæmorrhage, etc. Work in garden and grounds, games, and fishing, when no fever.
Friedrichsheim ...	Rest only when very weak or very feverish, particularly if patient desires it. Walking only according to strength.
Hohenhonnef ...	Rest for fever, hæmoptysis. Walking and respiratory exercise.
Ruppertshain ...	Rest in bed for fever. No form of exercise.
Halila (Gabrilowitch)	Absolute rest in bed for fever and hæmoptysis; rest in recumbent position in absence of fever. When catarrhal symptoms present in lungs, no form of exercise is allowed.
Braunwald ...	Febrile patients are kept in bed. Walking one and a half to three hours if temperature below 37·4° C. and pulse below 100.
Dr. Driver's ...	Febrile patients are kept at rest.
Sülzhayn	All patients rest, severe cases always in bed. Walking when no fever.
Montana	Febrile patients kept at rest.
Reknaes	All patients rest, febrile cases always in bed. Walking.

Sanatorium.	Answer.
Zarskoje	Depends on the individual case. Exercise, avoiding fatigue.
Rossclare	Rest when (1) much cough; (2) more fever than 98·6° F. in morning, or 100° F. after exercise; or (3) acute diarrhœa. Walking when temperature has been normal for a week.
Consumption Sanatoria, Scotland...	Exercise when morning (rectal) temperature is below 99° F.
Dunstone Park ...	Rest when the temperature is over 100°; this may be taken as a rough rule. Graduated walking, pulmonary exercise.
Grampian	In bed for a day or two on arrival, also whenever temperature has reached 100° F. on previous day. Graduated exercise and climbing if temperature below 99·4° F. on previous day.
Holne Chase ...	Rest only in febrile cases. Walking, golf, respiratory and Whiteley's exercises, when morning temperature (rectal) normal, and evening temperature not above 100° F.
Belzig	Rest if temperature is above 38° C. Pulmonary exercise when disease arrested.
Nordrach on Dee...	Rest during pyrexial stage. Walking according to case; in some cases chest exercises.
Trespoey	In bed when feverish. Frequent short walks.
Nordrach on Mendip	Walking if temperature is below 37° C. and is not raised above 38° C. after exercise.
Vale of Clwyd ...	Rest with morning temperature above 98·6° F.; bed with morning temperature above 99° F. Slow uphill walking when morning temperature below 98·6° F., or exertion temperature below 100·4° F., with due regard to effects.
Nordrach in Wales	Depends upon the individual and the experience of the physician. Roughly

Sanatorium.	Answer
	speaking, if the early morning temperature (rectal) is 98·6° F. or above, rest is indicated. If it is 99° F. or over, the patient must rest in bed. If the temperature rises during the day to 100·4° or over when the patient is at rest, absolute rest in bed is indicated until the temperature comes down. Walking is prescribed, but it is impossible to lay down a definite rule, as so much depends upon the individual. The amount is judged by the effect on the temperature taken immediately after the walk; if this rises to 100·4° F. or above, the patient rests in the afternoon and next morning the walk is a shorter one. If it does not rise so high, an afternoon walk is also taken, and the next morning walk may be increased; this, however, is only a rough idea of it.
Rostrevor	High temperature or hæmorrhage.
Linford	Bed when temperature is above 37° C. in the morning and above 38° C. at night habitually, but too much cough, expectoration, general weakness, as shown by the pulse and muscular power, etc., all indicate rest or bed sometimes. Slow uphill climbing is prescribed, the amount varying with each patient's strength, condition and temperature.
Canigou	If the body temperature exceeds 37° C. in the morning, bed. In other cases, either complete repose in the gallery or a little exercise which does not involve any fatigue or perspiration.
Guimar (Teneriffe)	Regulated climbing, beginning with twenty minutes daily. Absolute rest if temperature above 100° F.
S. des Pins ...	Rest in some cases when the temperature reaches 37° C. Respiratory, gymnastic, and Sanders's exercises are advised.

Sanatorium.	Answer.
Beauregard ...	Patients with fever are kept in bed. During menstruation, women in bed. Walking, skating, and graduated exercises.
Hauteville ...	Rest when there is fever.
Adirondack ...	Patients with an appreciable rise of temperature are allowed merely to walk to dining-room for meals, and to sit out-of-doors during the febrile period in the afternoon. Rest when the temperature is above 100° F., and sometimes in gastritis. Amount of rest taken by more febrile patients determined by rate of circulation, nutrition, and appetite. Walking, skating, driving, if temperature not above 99·2° F.
Victoria Hospital for Consumption, Edinburgh	Those who have fever or much circulatory disturbance are kept in bed or at rest on reclining chairs or couches.
Crooksbury ...	Rest in bed in cases of fever, weak circulation, hæmoptysis, great loss of weight, great weakness, rarely for dyspepsia. Walking, occasionally cycling, carriage exercise, deep breathing and singing, if maximum temperature under 100·4° F.—many exceptions.
Sharon	Febrile cases kept in bed. Exercise when no fever and condition of patient allows it; always stop short of fatigue. Respiratory exercise employed.
Winyah	Amount of rest and exercise varied according to state of heart and of temperature.
Colorado	At first it is often advisable to keep patients at rest.
Glockner	Patients kept in bed when the strength does not permit of exercise.
Durtol	Febrile cases kept at rest in fresh air.
Loslau	Kept in bed for fever.
Dr. Turban's Davos	Exercise when no fever.
Oderberg	Kept in bed for fever.

Sanatorium.	Answer.
Waldhof Elgershausen	Rest when the temperature is above 37° C., or if there is hæmoptysis.
Falkenstein ...	Absolute rest when hæmoptysis, fever, pleurisy, or acute disease is present.
Arosa	Dr. Jacobi believes in the utility of exercise whenever the patient is sufficiently strong.
Laurentian ...	Patients kept in bed when the temperature rises above 100° F. Exercise is only permitted when the physical signs show that the disease is quiescent.

APPENDIX VI

Showing the Character of the Personnel at Certain of the Larger Sanatoria

Proposed Sanatorium at Frimley (100 patients).—A medical superintendent, two assistant medical officers; a matron, six nurses; ten female servants, three male servants.

Falkenstein (120 patients).—A medical superintendent, three assistant medical officers; managerial staff of four; one waiter to eight or ten patients; total staff, male and female, indoor and outdoor, ninety-two.

Ruppertshain (122 patients).—A medical superintendent, two assistants; a secretary; a matron, five nurses (male and female); twenty-four male and female servants.

Harlaching (212 patients).—A medical superintendent, three assistant medical officers; a manager, two clerks; a matron, twenty-one nurses, and two male attendants; nine female and eight male servants, including engineering staff.

Krailing (120 patients).—A medical superintendent,

two assistants; a matron; twelve nurses and three male attendants, twenty-one male and female servants. The clerical work is done at Munich.

Belzig (80 patients) *and Bleichröder* (30 patients).—A medical superintendent, two assistant medical officers; a matron, a housekeeper, a sister in the office, two nursing sisters, an inspector who acts as secretary; a bath attendant for males, a laboratory attendant, a cook, four kitchenmaids and a kitchen boy, extra help being given by girls who are taught cooking; a laundress and four under-laundresses; a porter who keeps entrance and hall clean; four maids and two men-servants in the Verein-Anstalt, with two maids and a man-servant in Bleichröder-Stiftung. The waiting is done by men-servants, but occasionally women are employed for extra work. In addition there are an engineer, two stokers, a gardener, and a gardener's help.

APPENDIX VII

Showing the Different Types of Buildings exhibited by Existing Sanatoria

(*a*) Twenty-eight large sanatoria (eight for well-to-do, twenty for more necessitous cases) in which the patients and the administration offices are placed in *one large block*. No sanatorium is included in this section which contains less than sixty beds.

(*b*) Fifty-four sanatoria in which the patients are housed in a *varying number of different buildings*.

(*a*) *Those with a Single Large Block for housing Patients and for Administration.*—In this instance we do not include any sanatorium which has less than sixty beds.

Eight Sanatoria for Paying Patients.	Date.	No. of Beds.
Winyah	1878	60
Arosa	1887	65
Asheville	1898	75
Santa Catalina	1890	80
Canigou	1890	100
Hohenhonnef	1892	109
Leysin	1892	110
Schatzalpe	1900	120

Twenty Sanatoria for the Poor.	Date.	No. of Beds.
National Bournemouth	—	62
Malchow	1892	86
Loslau (£1 a week)	1898	87
Ruppertshain	1895	88
Basel (2.5 francs a day)	1895	100
Boserup	—	100
Cottbus	1900	100
Friederichsheim	1899	100
Frimley (Brompton proposed) ...	1902	100
Manchester (Halkin)	1900	100
Reknaes	—	100
Wilhelmsheim	1895	100
Nicolaj	1895	100
Edmundsthal (2 marks a day) ...	1899	103
Alland	1894	108
Oberkanfungen	1900	120
Oderberg	1897	120
Sülzhayn	1898	120
Albertsberg (£1 a week) ...	1897	122
Ormesson	1888	130

(*b*) *Those with a Varying Number of Different Buildings* (53 in number).—In this section of the Appendix it will be noticed that at many sanatoria there are a number

of separate houses for the patients, although the total number of these latter is as low as twenty. Further, some twelve of these sanatoria have no accommodation for patients in the administration block.

Name.	No. of Beds.	How Patients are housed, together with the Number of Patients in each Building.
Maitland House ...	8	4 in maintenance block, 4 in wooden building.
Hailey (future scheme)	12	A number of wooden sleeping châlets round maintenance block.
Trespoey	14	10 in main block, 4 in annexe.
St. Andreasberg ...	17	5 in one villa, 12 in maintenance block.
Altedor	18	9 in main block, 9 in bungalows.
Whitmead Hill ...	19	7 in maintenance block, 12 in another house.
Inglewood	20	12 in maintenance block, 4 sleeping shelters, 4 more in process of erection.
Mendip Hills ...	20	14 in maintenance block, 6 in sleeping châlets.
Woodburn... ...	20	10 in main block, 10 in wooden pavilion.
Crooksbury ...	20	12 in main block, 8 in another.
Alderney Manor ...	25	Administrative bungalow surrounded with wooden sleeping huts.
Rostrevor	25	13 in main block, 7 in sleeping bungalows, 5 in sleeping huts.
James Brown Sanatorium, Australia	25	In two blocks, male and female; separate maintenance block.
National Hospital, Ireland	34	Two houses.
Harth Forest Colony	35	Main block 25, 10 in small block, and a number of huts in summer.
Cotswold	37	One stone building 14 beds, several wooden ditto 19, sleeping shelters 4.

Name.	No. of Beds.	How Patients are housed, together with the Number of Patients in each Building.
Nordrach on Mendip	37	A colony of wooden houses; largest contains 12 patients.
Montefiore Home...	40	In two blocks.
Dr. Phillipi's ...	40	30 in main block, 10 in châlet.
Taitzi	40	20 in old castle, 20 in female block.
Tonsaasen	40 to 90	In six buildings.
Quisisana	41	24 in main block, 7 in another, 10 in doctor's house.
Muskoka Cottage Sanatorium	50	20 in maintenance block, 4 to 6 in a number of cottages.
Liverpool Hospital Sanatorium	50	Main block a few, a number of small blocks from 4 to 6.
Königsberg ...	50	36 in main block, rest in Dorchersche Barracken.
Heiligenschwendi...	52	Main block a few; two lateral pavilions.
Waldof-Elgerhausen	59	Two houses.
Chestnut Hill ...	60	A number of cottages.
Dr. Sanders's ...	62	26 in main block, 36 in two other blocks.
Hygeia	65	A few in maintenance block; two smaller blocks, and five cottages.
Schömberg ...	65	Old sanatorium and a number of houses in the village.
Bridge of Weir ...	66	One house with 26, one with 10.
Nordrach Colonie	70	In five houses.
Gabriels	70	Number of detached cottages.
Dr. Turban's, Davos	80	In maintenance block and in three villas.
Grabowsee... ...	80 in winter; 160 in summer	One house with 52, a wooden pavilion with 28, and new wooden pavilions containing 8 beds each.
Loomis	90	One house for 16 patients and one for 23; seven cottages containing 10, 8, 8, 7, 6, 4, and 5 patients.
Schwarzenbach ...	90	76 in main block, 14 in a pavilion.

Name.	No. of Beds.	How Patients are housed, together with the Number of Patients in each Building.
Adirondack ...	94	The maintenance block, containing a few beds, and twenty one-story cottages with 4 or 5 beds each.
Colorado	100	Some in maintenance block, with three smaller blocks.
Reiboldsgrün ...	108	In eight blocks, one containing 15 beds, another 34, another 26, another 15, another 22, another 12.
Hauteville	110	In three pavilions.
Falkenstein ...	112	One large block and one smaller block.
Laubbach	113	Main block 67, doctor's house 14, one villa 17, two villas 15.
Dr. Römpler's ...	120	Main building 100, two villas 20.
Dr. Lahmann's ...	(?)	A number of villas, shelters for sleeping.
Mont Bonmarin ...	120	In three blocks.
Boserup	120	Two buildings.
Albertsberg ...	140	122 in main block, rest in two pavilions.
Ventnor Hospital ...	155	In eleven blocks. Eight small blocks with 12 beds each; maintenance block with 18, another block with 21.
Massachusetts State Hospital	175	In ten pavilions, five containing 20, five 8 beds.
Dr. Weicker's ...	275	Main block has a few beds, three blocks for 80 women, together with villas and houses.
Görbersdorf ...	335	104 in main block; three villas, with 13, 24, and 16 respectively; and a number of houses.

APPENDIX VIII

GIVING THE NAMES OF FORTY-THREE SANATORIA WHERE THE KITCHEN OR DINING-ROOM, OR BOTH, ARE COMPLETELY CUT OFF FROM THE BLOCKS IN WHICH THE PATIENTS' BEDROOMS ARE PLACED

1. *Both dining-room and kitchen* in separate block or annexe—*i.e.*, cut off from the patients' quarters—in twenty-nine sanatoria: Falkenstein, Hohenhonnef, Nikolaj, Basel Davos, Linford, East Anglian, Cottbus, Nordrach Colonie, Altena, Liverpool Hospital Sanatorium, Dundee, Crooksbury, Cotswold, Nordrach on Dee, Massachusetts, Albertsberg, German Sanatorium at Davos, Loomis, Chestnut Hill, Adirondack (all but a few beds), Dr. Weicker's Krankenheim, Harlaching, Heiligenschwendi, National Hospital for Consumption (Ireland), Hailey (in future scheme), Alderney Manor, Grabowsee, James Brown Sanatorium, and London Open-air.

2. *Kitchen only* in a separate block or annexe in seven sanatoria: Hygeia, Alland, Lehrecke, Ruppertshain, Alexander, Grampian, Pasteur.

3. *Dining-room only* in separate block or annexe in seven sanatoria: Canigou, Bellevue, Shotley Bridge, Maitland House, Rudgwick, Nordrach on Mendip, Belzig.

APPENDIX IX

SHOWING THE NUMBER OF STORIES WHICH THE PATIENTS MAY HAVE TO CLIMB, IN ORDER TO GET TO THEIR BEDROOMS, AT EIGHTY-NINE SANATORIA

(*a*) Forty-eight sanatoria which house less than fifty patients.

(*b*) Twenty sanatoria which house more than fifty patients and consist of several buildings.

(*c*) Twenty-one sanatoria (fourteen for the poor and seven for the well-to-do) which house more than fifty patients and consist of one large block, which may or may not, however, include the administration rooms.

Note.—In those cases in which there are several buildings of a different number of stories, we have taken the buildings which contain the greatest number of patients as being representative. Further, it may be mentioned that the number of stories of any recent extension to existing sanatoria which contain bedrooms for patients has seldom exceeded two, even in the case of those one-block sanatoria mentioned under heading (*c*).

(*a*) Out of forty-eight sanatoria which house less than fifty patients, twenty-five consist of either two- or one-storied buildings. Many of the others were adapted from existing buildings.

(b) Twenty Sanatoria which house more than Fifty Patients and consist of Several Buildings.

Name of Sanatorium.	No. of Beds.
1. *One story high*—	
Adirondack	94
Grabowsee	80 winter 160 summer
Massachusetts	175
Muskoka	50
Albertsberg	140
2. *Two stories high*—	
Heiligenschwendi	52
Nordrach Colonie	70
Liverpool	50
Schwarzenbach	90
Villiers-sur-Marne	220
Loomis (many in one-storied buildings)	90
Chestnut Hill	60
Harlaching	250
Bridge of Weir	80
Waldhof Elgershausen	59
3. *Three stories high*—	
Mount Bonmorin	120
Ventnor	155
4. *Four stories high*—	
Römpler	120
Falkenstein	112
Dr. Turban's	80

(*c*) *Twenty-one Sanatoria which house more than Fifty Patients and consist of One Block, which may or may not, however, include the Administration Rooms. Of these, Fourteen are for the Poor, Seven for the Well-to-do.*

Name of Sanatorium.	Date.	Whether for the Poor or not.	No. of Beds.
1. *One story high*—			
Ormesson	1888	Yes	130
2. *Two stories high*—			
Stiege	1897	Yes	58
Brompton projected ...	1902	Yes	100
Reknaes	Adapted	Yes	100
National Sanatorium for Consumption	Adapted	Yes	62
3. *Three stories high*—			
Winyah	1878	No	60
Canigou	1890	No	100
Oderberg	1897	Yes	110
Manchester projected ...	1902	Yes	100
Wilhelmsheim	1900	Yes	100
4. *Four stories high*—			
Arosa	1887	No	65
Asheville	1898	No	75
Schatz Alp	1900	No	120
Ruppertshain	1895	Yes	88
Alland	1894	Yes	108
Davos Dorf (new)	1898	Yes	65
Loslau	1898	Yes	87
Basel Davos	1895	Yes	100
5. *Five stories high*—			
Hohenhonnef	1892	No	109
Leysin	1892	No	110
Sülzhayn	—	Yes	120

APPENDIX X

SHOWING WHETHER BETTER RESULTS ARE OBTAINED IN ROOMS OF ANY PARTICULAR ASPECT IN THIRTY SANATORIA IN WHICH SOME OF THE ROOMS HAVE DIFFERENT ASPECTS

Statement.	No. of Sanatoria.	Names of Sanatoria.
No	24	Moorcote, Nordrach Colonie, Rudgwick, Cotswold, Montefiore Home, Hohenhonnef, Ruppertshain, Braunwals, Oderberg and Gluckhauf, Falkenstein, Reknaes, Rossclare, Nordrach on Mendip, Nordrach in Wales, Canigou, Sanatorium des Pins, Montana, Linford, Adirondack, Rostrevor, Laurentian, Basel, Durham.
Yes	6	Zarskoje, on sunny side; Consumption Sanatoria of Scotland, south; Trespoey, south; Victoria Hospital, Edinburgh, south; Loomis, south; Denstone Park, south and east.

APPENDIX XI

Showing the Aspect of the Majority of the Bedrooms in Seventy-two Sanatoria

Aspect of the Majority of the Rooms.	No. of Sanatoria.	Names of Sanatoria.
All directions.	9	Hygeia (beds in main building), Nordrach on Mendip, Rudgwick (six south), Vale of Clwyd (all except east), Nordrach in Wales, Sanatorium des Pins; most villas at Nordrach Colonie; Harbourne, Durham (all except north).
S.	38	Sülzhayn, Ventnor, Montefiore Home, Bridge of Weir, Dundee, National (Ireland), Crooksbury, London Open-air, Anstalt at Nordrach Colonie, Davos German, Rostrevor (some rooms west), Overton Hall, Cotswold, Mundesley, Nordrach on Dee, Hygeia (all the cottages), Dr. Sanders's, Chico Springs, Loslau, Albertsberg, Oderberg, Felixstift, Fernsicht, Berka, Alexander, Nikolaj, New Davos, Montana, Braunwald, Holne Chase, Belzig, Loomis, Consumption Sanatoria of Scotland, Moorcote (some rooms west), Whitmead Hill, Sharon, Chestnut Hill, Manchester.
S.W.	3	Winyah, Hohenhonnef, half of the rooms at Rossclare.
S.S.W.	4	Bournemouth, Heiligenschwendi, half of the rooms at East Anglian, and Brompton (proposed).
With both S. and S.W. aspect.	7	Liverpool, Dunstone Park, Stourfield Park, Sunny Nook, Arosa, Hauteville, Canigou.
S.E.	8	Falkenstein, Whitehaven, Adirondack (also east), Grampian, Ruppertshain, Königsberg, Guimar (and south), half of the rooms at Rossclare.
S.S.E.	5	Schömberg, Leysin, Linford, half of East Anglia, Brompton (proposed).
E.	1	Laurentian.

APPENDIX XII

Showing the Cubic Capacity of Single-bedded Rooms in Twenty-eight Sanatoria.

Note.—In those sanatoria in which the bedrooms are of different sizes the smallest size is taken.

Cubic Feet.	No. of Sanatoria.	Names of Sanatoria.
2,000–3,000	11	Schömberg, Laubbach, Las Vegas, Hohenhonnef, Colorado, Canigou, Trespoey, Davos (Dr. Turban's), Denver, Mont Bonmarin, Lindheim.
1,500–2,000	10	Ventnor, Linford, Inglewood, Overton Hall, Rossclare, Tonsaasen, Grampian, Woodburn, Dr. Michaeli's, Pitkejärvi.
1,000–1,500	6	Nordrach Colonie (Anstalt), Brompton (proposed), White Gables, London Open-air, Quisisana, Braunwald.
Under 1,000	1	Cotswold.

APPENDIX XIII

Showing the Height of Single-bedded Rooms in Twenty-one Sanatoria

Note—In those sanatoria in which the bedrooms are of different heights the lowest is taken.

Feet.	No. of Sanatoria.	Names of Sanatoria.
14¾	1	Alexander.
13	4	Falkenstein, Hohenhonnef, Inglewood, Las Vegas.
12	1	Overton Hall.
11½	2	Denver Home, Lindheim.
11	4	Woodburn, Grampian, Mont Bonmarin, Brompton proposed (some rooms).
10	6	Cotswold, Rossclare, Colorado, White Gables, Nordrach Colonie (Anstalt), Tonsaasen, Brompton proposed (some rooms).
9 ft. 2 in.	1	London Open-air.
9	1	Linford.
8½	1	East Anglian.

APPENDIX XIV

Showing the Floor Space of Single-bedded Rooms in Thirty-one Sanatoria

Note.—In those sanatoria in which the bedrooms are of different sizes the smallest is taken.

Square Feet.	No. of Sanatoria.	Names of Sanatoria.
400–500	1	Alexander.
300–400	2	Sunny Nook, Denver Home.
200–300	5	Winyah, Colorado, Hygeia, Glockner, Denver Home.
150–200	9	Linford, Las Vegas, Mont Bonmarin, Lindheim, Woodburn, Nordrach Colonie (Anstalt), Tonsaasen, Rossclare, Loomis.
100–150	11	Overton Hall, Grampian, London Open-air, Adirondack, East Anglian, Inglewood, Crooksbury, White Gables, Sharon, Harbourne, Brompton (proposed).
100 or less	3	Whitmead Hill, Cotswold, Hygeia.

APPENDIX XV

Showing the Number of Recreation-Rooms in Fifty-two Sanatoria

In certain sanatoria included under the first heading, such as Nordrach Colonie and East Anglian, a portion of the dining-hall is used for recreation purposes.

Recreation-rooms.	No. of Sanatoria.	Names of Sanatoria.
Dining-room only	24	Whitehaven, Hauteville, Nordrach Colonie, Moorcote, Rudgwick, Cotswold, Friedrichsheim, Reknaes, Consumptive Sanatoria of Scotland, Rossclare, Dunstone Park, Holne Chase, London Open-air, Nordrach on Mendip, Nordrach in Wales, Guimar Hospital, Rostrevor, Crooksbury, East Anglian, Las Vegas, Alland, Krailling, Overton Hall, Durham.
One recreation-room in addition to dining-room	17	Loslau, Dannensfels, Whitmead Hill, Braunwald, Forster's Green, Grampian, Quisisana, Rossclare, Lindheim, Dutch Davos, Vale of Clwyd, Albertsberg, Zellerfeld, Berka, Tonsaasen, Mundesley, Lehrecke.
Two recreation-rooms in addition to dining-room	11	Boserup, Nordrach on Dee, Trespoey, Villiers-sur-Marne, Sülzhayn, Fernsicht, Marzell, New Davos, Leysin, Ruppertshain, Brompton (proposed at Frimley).

APPENDIX XVI

Showing Methods of Ventilation at Seventy-six Sanatoria

Method.	No. of Sanatoria.	Names of Sanatoria.
Open windows alone (some having fan-lights into corridors)	19	Ruppertshain, Bournemouth, East Anglian, National (Ireland), Forster's Green, Cotswold, Canigou, Durtol, Falkenstein, Laubbach, Sanders's, Malchow, Tonsaasen, Reknaes, Leysin, Montana, Basel, Heiligenschwendi, Braunwald.
Open windows, together with various ventilating holes in walls, below roof or above or below windows	13	Hailey, Grampian, Woodburn, Adirondack, Hygeia, Glockner, Alland, Mont Bonmarin, Villiers-sur-Marne, Albertsberg, Stiege, Lindheim, Turban.
Open window together with simple shafts	12	Crooksbury, Winyah, Colorado, Alland, Brehmer, Schomberg, Loslau, Oderberg, Felixstift, Altena, Harlaching, Maria.
Open window together with extractors	10	*Shafts with Hot Pipes.*—Manchester Hospital, Ventnor, Villiers-sur-Marne, Nikolaj, Bridge of Weir (given up), Grabowsee, Berka. *Shaft with Electric Extricator.*—Krailling, Stourfield Park, Brompton (proposed at Frimley).
Open windows, together with open fires or chimneys	11	National (Ireland), Loomis, Winyah, Mont Bonmarin, Hohenhonnef, Albertsberg, Arlen, Bridge of Weir, Alexander, Leysin, London Open-air, The Home (Denver),
Open windows with warm or cold air forced in	11	Villiers-sur-Marne, Oderberg, Felixstift, Altena, Quisisana, Maria. *Plenum System abandoned.*—Ventnor, National (Ireland), Forster's Green. *Hot Air abandoned.*—Victoria Hospital (Edinburgh).

APPENDIX XVII

Showing the Kinds of Heating Apparatus used in 110 Sanatoria

System.	No. of Sanatoria.	Names of Sanatoria.
Open fires	17	Bournemouth, Victoria, Bridge of Weir, Hailey, Whitmead Hill, Overton Hall, Stourfield Park, Grampian, Rostrevor, Mundesley, Hygeia, Tonsaasen, Moorcote, S. des Pins, Canigou, London Open-air, National (Ireland).
Hot-water pipes and radiators.	24	Bournemouth, Crooksbury, Whitmead Hill, Nordrach on Mendip, Woodburn, Rostrevor, Loomis, Brehmer, Dr. Römpler's, Stourfield Park, Cotswold, Hohenhonnef, Loslau, Mundesley, Arlen, Nikolaj, Davos Dr. Turban's, Heiligenschwendi, Braunwald, Boserup, Friedrichsheim, Vale of Clwyd, Adirondack.
Low or high pressure steam-pipes and radiators	38	Ventnor, East Anglian, Nordrach on Dee, Loomis, Glockner, Denver Home, Las Vegas, Alland, Reiboldsgrün, Dr. Michaeli's, Falkenstein, Nordrach Colonie, Schömberg, Malchow, Oderberg, Glückauf, Felixstift, Königsberg, Berka, Altena, Marzell, Krailling, Harlaching, Arosa, Davos Dr. Turban's, New Davos, Montana, Basel Davos, Chico Springs, Luitpoldheim, Montefiore Home, Davos German, Ruppertshain, Braunwald, Sülzhayn, Belzig, Beauregard, Montana.
Hot-air	7	Manchester, National (Ireland), Forster's Green, Sharon, Chestnut Hill, Brehmer, Friedrichsheim.
Closed stoves, iron or porcelain	21	Brehmer, Dr. Weicker's, Reiboldsgrün, Falkenstein, Dr. Sanders's, Dr. Weicker's Krankenheim, Stiege,

System.	No. of Sanatoria.	Names of Sanatoria.
Closed stoves, iron or porcelain—(*continued*)	21	Zellerfeld, Rehberg, Tonsaasen, Lindheim, Quisisana, Alexander, Maria, Arosa, Davos Dr. Turban's, Dutch Davos, Military Hospital Zarskoje, Trespoey, Nordrach in Wales (palace stoves), Waldhof-Elgershausen.
Electric radiator	3	Liverpool, Nordrach on Dee (some rooms), Nordrach Colonie (one villa).

In some sanatoria two or more methods are employed.

APPENDIX XVII (*a*)

A Discussion on the Advantages and Disadvantages of Various Methods of Heating

Open Fires — Stoves — Hot-water Pipes — Low-pressure Steam—High-pressure Steam—Details of Boiler, etc., for High or Low-pressure Water System—Details of High-pressure Water System.

I. OPEN FIRES.

These afford the most cheerful method of heating a room; their first cost is much less than that of any hot-pipe system; they keep the air fresher than hot pipes owing to chimney draught, whilst rooms in which they are used require painting less frequently than those heated with other systems. On the other hand, they give rise to dust, both when in use and when they are cleaned; they entail greater service, cost more per annum than pipes, give an unequal distribution of heat, are unsuitable for use at a sanatorium—as heat is required chiefly during the night,

if at all—and, according to Stevenson and Murphy, the air in the rooms in which they are used is more highly charged with organisms.

II. STOVES.

These afford the cheapest form of heating a room, both with regard to the initial expenditure and the annual cost; they are probably more effective heaters than open fires, and they are convenient in that they may be fed from the corridor. On the other hand, they are more liable than fires to give rise to smoke, they entail greater labour of service, require more attention than, and are not so cheerful as, open fires, are liable to get out of repair, and are apt to char any dust which may come in contact with them.

III. HOT-WATER PIPES.

The advantages and disadvantages of these may be tabulated as follows:

Advantages.

1. Less labour in service than if stoves or open fires are used.
2. More equal distribution of heat.
3. Repairs easily made without much disturbance.
4. Annual cost slightly less than that of open fires, but rather more than that of stoves.

Disadvantages.

1. Not so cheerful as open fires.
2. First cost more than t hat of stoves or oen fires, owing to the laying of pipes, boilers, etc.
3. Diminish the humidity of the air.
4. Are apt to char any dust which may come in contact with them.

A. LOW-PRESSURE SYSTEM.

For small rooms low-pressure hot-water pipes are generally more desirable than those systems which employ steam at high and unknown pressure.

Advantages.

1. The radiators in each room are simple in construction, and need not be permanent fixtures. They can be fitted so as to revolve from side to side on hinges, in order to enable a thorough cleansing of the floor spaces underneath them to be made.
2. They do not dry the air to anything like the same extent as high-pressure pipes.
3. The low pressure at which they work renders them less liable to leakage or bursting, and hence less dangerous than high-pressure pipes.
4. The temperature of the room in which they are fitted is regulated with great ease, and when they are once efficiently fitted they require little or no attention, whilst repairs are infrequent.
5. The boiler is one which burns coke, and though it must be of slightly larger dimensions than those used for the high-pressure system, yet it need not be of inconvenient size.

B. HIGH-PRESSURE SYSTEM.

Advantages.

1. Owing to the high pressure at which the steam is circulating in these pipes, the temperature of the room in which they are fitted can be raised much more quickly than when the low-pressure system is adopted

2. The radiators occupy less space and are somewhat smaller than the low-pressure ones, but they must be permanently fixed, and so are immovable for cleansing purposes.
3. High temperatures can be maintained, and maintained with greater ease than is the case with the low-pressure system.
4. A relatively smaller coke-burning boiler is required than is necessary for the low-pressure system.
5. The small high-pressure pipes are slightly cheaper in first cost than the large low-pressure pipes.
6. In small rooms, 10 feet of a 4-inch pipe to every 1,000 cubic feet of space will give a temperature of about 55° F.

DETAILS OF BOILER, FURNACE, ETC., FOR LOW- OR HIGH-PRESSURE SYSTEM.

Re Smoke.—The boiler for either system is constructed to burn coke as fuel, and, if properly stoked and attended to, gives rise to very little smoke save for a few minutes when the furnace is first lighted for the day.

Re Position and Space.—The actual space required is not large, though the low-pressure system, as already intimated, requires a boiler of slightly larger dimensions than the high-pressure system. The boiler should be placed in an excavated room in the basement, so that the mains, carrying the hot water in jacketed pipes, can be placed along, or under, the corridors in the form of two diverging arms. The water, after circulating through the rooms, is brought by return pipes back to the boiler.

Storage of Coke.—In addition to appointing a reliable man to stoke the fire, it is advisable to provide a small room adjoining the boiler-room in which a sufficient supply of coke can be stored.

DETAILS OF HIGH-PRESSURE WATER SYSTEM.

Perkins' system demands the use of a series of water-pipes of wrought iron and sufficiently strong to withstand a pressure corresponding to very high temperatures (pipes $\frac{15}{16}$ inch external diameter). A part of the circuit is coiled up and exposed to the heat of the furnace. The water circulates with great rapidity, in spite of narrow bore of pipes. The temperature is regulated by fixing the proportion of the length of pipe in the furnace to the length outside. This is usually 1 to 10. Thus, a 1,500 feet long run of pipe will have in the furnace a coil of only 150 feet. The high temperature of the pipes, though useful and desirable from the fact that the distribution of heat takes place to a greater extent by radiation than is the case with low-pressure systems, makes it essential that proper precautions should be taken in the working of this system.

APPENDIX XVII (*b*)

General Specification for the Necessary Electric Installation in the Proposed Sanatorium

Until the site selected is known, the means of producing the necessary electrical energy cannot be definitely decided upon; water-power if available is, of course, to be preferred. Failing this, the next best from the sanatorium point of view will be power generated by oil-engines. It is to be feared, however, that the cost will render this out of the question, in which case gas-engines will have to be used, the gas being produced by one of the various methods which do not entail the use of coal, unless ordinary mains are available.

Distribution.—From a convenient central position in the

administration block separate cables for the lighting and heating services to be run underground to independent distribution boards, situated in a convenient position in each of the isolated patients' blocks. The circuits are then to be split up into a convenient number, each protected by a double pole safety-fuse for controlling the individual lights and radiators throughout the building. The whole of the *interior wiring*, both for the lighting and heating services, to be run in brazed and screwed tubing (the lighting and heating services to be in separate tubes) provided with suitable junction-boxes let into the walls or laid under the floors. In order to prevent any accumulation of dust, in no portion of any building used by patients are the conduits to be run on the surface. The *switches* controlling the lights are to be sunk flush and covered with a plain flat cover, leaving only the button exposed. so as to collect as little dust as possible. *Fittings* of either the bracket or pendant type to be of a plain description. Pendants to consist of an enamelled tube screwed to the service tubing at the one end, and to the fitting at the other, the whole arranged so that it can be readily cleaned and freed from dust by wiping with a damp cloth, without injury to the wires.

The heating of the various portions of the building is to be done with *electric radiators* of a plain and substantial description designed to obviate, as far as possible, the accumulation of dust, and at the same time to be readily removed and cleaned. Each radiator to be wound with two or more independent coils, each provided with a switch to allow the degree of warmth to be regulated as required. The radiators to be supplied by separate services to the lights, and a wall socket and switch, both sunk flush, to be placed in a convenient position in each room. The flexible cord from the radiator to the wall

socket must be protected by an indiarubber or other approved flexible covering not injured by damp and readily cleaned.

Kitchen.—The whole of the utensils used for cooking are to be worked by means of electricity. A specially arranged switchboard to be fitted in the kitchen, supplied from the heating service, from which the various utensils will be controlled. The switchboard to be provided with a switch and fuse for each of the larger utensils, such as ovens and plate-warmers, which will be practically fixed, and a wall socket, plug, fuse, and switch for each kettle, saucepan, frying-pan, or vegetable steam-cooker required. A ventilating pan, to extract the air from the kitchen and to remove the fumes produced by cooking, to be fitted complete with controller and switch. Each block to be supplied with a small *electric heater* for such purposes as keeping food warm.

Laundry Fittings. — The usual laundry machines, including a hydro-extractor, to be worked by electric motors, either by directly coupling a small motor to each machine or by countershafting and belts, the countershaft being driven by a large motor capable of supplying any power that may be required. A set of electric irons, together with suitable connections for convenient use, to be provided in the ironing-room. Electric fans, to extract the steam from the laundry and to provide draught to the drying-rooms, to be provided.

The dining-room, recreation-room, and the other parts of the buildings mentioned in the text as requiring them, to be provided with electric fans.

APPENDIX XVII (*c*)

Showing Temperature to which the Bedrooms are heated in Thirty-nine Sanatoria

Temperature.	No. of Sanatoria.	Names of Sanatoria.
Rooms are not heated at all	4	Rudgwick, Guimar (unnecessary because of climate), Rossclare, Nordrach in Wales.
Where little attention is paid to the temperature; in most cases this is about the same as that of the outside air	13	Moorcote, Cotswold, Nordrach on Dee, Nordrach on Mendip, Luitpoldheim, Consumption Sanatoria (Scotland), Trespoey, San. des Pins, Holne Chase, Nordrach Colonie, Canigou, Chico Springs, Durham.
40° to 50° F. in winter	5	Boserup, 50° F.; Grampian, 43°; Linford, 40° to 50°; Basel, 48°; Whitehaven, 48°.
50° to 60° F. in winter	13	Hauteville, Ruppertshain, Halila, Vale of Clwyd, Oderberg and Glückauf Braunwald, Dunstone Park, Belzig, Hauteville, Beauregard Montana, Crooksbury, Montefiore Home.
60° F. or over in winter	4	Adirondack, Loomis, Laurentian, Sülzhayn.

APPENDIX XVIII

A Discussion on the Efficacy of Various Chemical, Steam, and other Methods of Disinfecting, and an Account of the Requirements of a Disinfecting-Station

General Methods—Chemical Methods—Burning—Boiling—Hot Air—Various Forms of Steam—Requirements of a Disinfecting-Station—Description of Steam-Disinfector.

Disinfection—that is, the complete destruction of micro-organisms and their spores—may be carried out—

(*a*) By exposing the infected articles to the action of certain chemical substances, which act as *direct* poisons to the micro-organisms, such as perchloride of mercury or carbolic acid.

(*b*) By exposing the infected materials to oxidizing or to reducing agents. Neither of these processes, however, are of practical value when used on a large scale.

(*c*) By exposing the infected articles to high temperatures obtained by means of—

1. Fire.
2. Boiling.
3. Hot air.
4. Steam.

(*a*) CHEMICAL METHODS.

Of late years an enormous number of experiments have been made with regard to the action of various chemical substances upon tubercle bacilli. In nearly all the chemical agent is allowed to act upon the bacilli for a varying time, and the subsequent activity of the micro-organisms is then ascertained by inoculation experiments. The

results which have been obtained with regard to some of these chemical agents may be tabulated as follows:

Corrosive Sublimate or Perchloride of Mercury.—Schill and Fischer found that a strength of 2 in 1,000 was not fatal to the bacilli in ordinary sputum, even after twenty-four hours. Steinitz found that a 5 in 1,000 strength destroyed bacilli in sputum in one and a half hours, but that a 2 in 1,000 solution required three to five hours, and a 1 in 1,000 solution six to eight hours. He also showed by comparative tests that in the case of infected handkerchiefs sublimate was superior as a germicide to formalin or iodine trichloride. Delépine and Ransome confirmed Schill and Fischer's observations. Yersin, using cultures of tubercle bacilli in which there was no mucus or other coagulable material, showed that it took ten minutes to kill the bacilli with a solution of 1 in 1,000. T. H. Elliott (1902) has shown that a strength of 1 in 500 does not destroy tubercle bacilli in the central portions of nummular sputum even after twenty-four hours. It has further been pointed out that the application of sublimate must be very freely made, as any organic matter tends to reduce it.

Carbolic Acid.—Schill and Fischer found that a 5 per cent. solution of carbolic acid is not fatal to the bacilli of tuberculous sputum for at least twenty-four hours, even if the amounts of sputum and carbolic acid are the same. Gerlach found 5 per cent. carbolic acid ineffectual after twenty-four hours. Spengler found that, when a 10 per cent. solution was mixed with an equal quantity of sputum, some tubercle bacilli retained their virulence at the end of twenty-four hours. Yersin, on the other hand, claims to have demonstrated that infected sputum loses its virulence when exposed to a 1 per cent. solution of carbolic acid for one minute, or to a 5 per cent. solution

for thirty seconds. In the light of more recent work, these observations of Yersin could not have been made with nummular sputum, for T. H. Elliott has shown that a solution of 1 in 20 carbolic acid does not affect the central portions of nummular sputum, even after twenty-four hours. Jaeger asserts that 5 per cent. carbolic acid destroys the bacilli in dried sputum in five minutes.

Formaldehyde.—Steinitz has shown that this agent in the form of vapour is able to destroy the bacilli *in dried sputum*, but that when it is used in solutions of 10 per cent. and 25 per cent. (of the commercial 40 per cent. formaldehyde known as formalin) ordinary sputum is not affected. Muthu has recently spoken highly of formaldehyde for room-disinfection. Kenwood in 1897 published the following conclusions at the Leeds Sanitary Congress :

1. Simple evaporation of solutions of *formic aldehyde* is inefficient when tested bacteriologically, as a large proportion of gas is polymerized into trioxymethylene, which gives off aldehyde very slowly.
2. Trillat's autoclave is the best of all methods for disinfecting a room by means of formic aldehyde. A 40 per cent. solution of formic aldehyde is heated under pressure in an autoclave provided with a thermometer and a pressure-gauge, and a little chloride of calcium is placed in the solution. Practically all the aldehyde is given off before the water comes off as steam, as the boiling-point of the calcium chloride solution is well above 100° C., while the gas comes off below the temperature.

The drawbacks to this apparatus are its weight and cost (£18), and the attention it requires.

The cost of disinfecting an ordinary room, apart

from the cost of apparatus, is about 2s. 6d., as one and a half tubes of formalin are required for 3,000 cubic feet of space.

3. Velvet, cloth, bronze, gilt, silk, etc., are not damaged by formic aldehyde in any form. The vapour, on the other hand, will not penetrate bulky articles, such as carpets and the like.

Novy and Waite in 1898 gave the following practical directions: (1) All cracks or openings in the plaster or in the floor or about the doors and windows should be caulked tight with cotton or with strips of cloth. (2) The linen, quilts, blankets, carpets, etc., should be stretched out on a line, in order to expose as much surface to the disinfectant as possible. They should not be thrown into a heap. Books should be suspended by their covers, so that the pages fall open and are freely exposed. (3) The walls and floors of the room and the articles contained in it should be thoroughly sprayed with water. If masses of sputum have collected on the floor, they should be soaked with water and loosened. No vessel containing water should, however, be allowed to remain in the room. (4) One hundred and fifty centimetres (5 ounces) of the commercial 40 per cent. solution of formalin for each 1,000 cubic feet of space should be placed in the distilling apparatus, and be distilled as rapidly as possible. The keyhole and spaces about the door should then be packed with cotton or cloth. (5) The room thus treated should remain closed for at least ten hours. If there is much leakage of gas into the surrounding rooms, a second or third distillation of formaldehyde, at intervals of two or three hours, should be made.

Chloride of Lime.—Delépine and Ransome found that a solution of chlorinated lime of the strength of 1½ ounces to the gallon (at which percentage its use is attended by

no discomfort) effectually destroys tubercle bacilli in any sputum which may have soiled the walls or furniture. These authors have been confirmed by Coates, and it is now recommended that wall-papers should be disinfected by this agent. Disinfection must be repeated three or four times in succession; by starting each time at the same corner of the room, each layer has time to penetrate into the paper, and to dry, partially, before the next is applied. The room should be sealed, and a small petroleum stove, together with a large basin of the disinfectant, used. In the basin, which is placed above the stove, a small capsule containing strong hydrochloric acid should be immersed, as this insures the necessary acidity of the air. Disinfection is complete in three hours, but the paper is destroyed in the process. Clothes (except silks, which are injured) may be disinfected by chlorinated lime, but must be well washed afterwards in order to remove the salt. Furniture and metal fittings must also be washed with water after the use of this substance. With regard to sputum in bulk, Delépine says that it is best mixed with an equal quantity of 1 in 50 chlorinated lime, as weaker solutions act too slowly on the tubercle bacilli.

Other Disinfectants.—Both Gerlach and Spengler have shown that, of 5 to 10 per cent. solutions of creolin, lysol, and aseptol, only lysol, which is comparatively expensive, is efficacious. Naugoth made emulsions of sputum and solutions (from $\frac{1}{10}$ to 1 per cent.) of iodine trichloride, and found that the germs were destroyed within an hour. Steinitz, however, found that this agent was not reliable, and that a 10 per cent. solution required over three hours to destroy the bacilli. Steinitz also showed that copper sulphate was inefficacious, as was hydrochloric acid when less than 10 per cent. solutions were employed. Delépine and Ransome found euchlorine, chlorine, and sulphurous

acid useless, and in this they have been confirmed by Koch and his pupils. Wood vinegar is said to kill bacilli in six hours, and to lessen the unpleasant aspect of the sputum.

Summary of the Value of Chemical Methods.—We see, then, that chemical reagents, with the exception of chlorinated lime, and possibly lysol, do not act satisfactorily in sterilizing ordinary sputum—*i.e.*, sputum which is not dried in a thin layer—the reason being that the outer portion of the nummular matter is rapidly coagulated by the formation of some albuminate, and so prevents the penetration of the reagent to the central portions. One word may be said here about *bread* as a means of disinfecting rooms. Loeffler showed, on the basis of Esmarck's experiments, that if painted or papered walls are rubbed down with bread, and the crumbs afterwards burnt, disinfection is efficiently carried out. Coates has, however, proved that this is only true of dry dust, and that when the walls have been directly soiled with sputum, rubbing with dough is useless.

(*c*) 1. *Fire-burning.*—This is a most efficient and certain method of dealing with the disinfection of valueless articles, such as infected rags, papers, and similar goods, old mattresses, pillows, and clothes, when these are no longer required. Sputum, paper handkerchiefs, and similar articles, should also be destroyed by this means.

2. *Boiling.*—Moeller (1901) boiled nummular sputum for ten minutes, and then found that the bacilli in the central portions infected guinea-pigs. Amongst the numerous researches on this point, we may mention those of Schill and Fischer, who found that the bacilli were killed after the fluid had been boiled for thirty minutes. According to Sternberg (1887), exposure for twenty minutes to 60° C. rendered tubercle bacilli harmless. Yersin put the temperature at 80° C. For articles that

will stand it, boiling water may be relied on as an efficient means of disinfection, provided, of course, that it is conscientiously carried out. It is necessary, however, that prior to boiling, the grosser dirt should be removed by a preliminary soaking in cold water, because the temperature of boiling water will otherwise indelibly fix organic stains in textile substances, and thus permanently discolour the material, linen or what not. It should be remembered that leather articles cannot be boiled; these articles are always difficult to disinfect, hot air being the only applicable method. The efficiency of boiling is very much added to if the boiling-point is raised to 102° or 103°, as it may be by the use of sodium bicarbonate or other substances. Sodium bicarbonate is also of value—provided that the temperature is very gradually raised—in that it dissolves, or in some other way prevents, the formation of the coagulation envelope, and so enables the central bacilli to be dealt with. This method must be conscientiously performed by a trustworthy individual if it is employed for cleansing sputum-flasks, and must be continued for at least half an hour if all micro-organisms and their spores are to be destroyed.

3. *Hot air* is not often used nowadays as a means of disinfection. It is, however, especially applicable to those articles which will not stand boiling, such as bedding, blankets, carpets, etc. Scorching not infrequently takes place, owing to the prolonged exposure to which the articles must be subjected; consequently, the method has been almost entirely discarded in favour of steam, which is not only more practical, but more efficient and rapid in its working.

The objections to dry heat as a means of disinfection may be enumerated as follows:

(*a*) Slow and tedious process.

(*b*) The heat penetrates bulky articles extremely slowly, whilst the spores in the centre of infected articles are frequently unaffected.

(*c*) Scorching of goods often occurs.

(*d*) The temperature of the interior of the goods is never known with certainty.

(*e*) Great difficulty is experienced in practice in maintaining a uniform distribution of the heat.

4. *Steam*, especially when it is under pressure, penetrates bulky articles far more readily than dry heat in any form, and on this account alone is to be recommended. Schill and Fischer found that steam killed the bacilli in fifteen minutes, whilst Grancher and Des Gennes state that steam is vastly superior to any chemical disinfectant. Spores and micro-organisms rapidly succumb, and this method in one or other of its various forms is now universally employed.

Disinfection by steam may be carried out in—

(*a*) Stoves in which *steam without pressure* is used; this is a cheap and effective method in actual practice, but a slow and tedious one, and cannot be recommended.

(*b*) Stoves or boilers in which *steam at low pressure* (2·5 pounds per square inch) is employed. As it is impossible in this way to obtain a temperature of above 110° C., this method is rapidly giving place to the following more practical one:

(*c*) Stoves or boilers in which *steam at high pressures* used. A temperature of from 115° to 120° C. can be obtained in this way, and any article, no matter how bulky, is made absolutely sterile when it is exposed to this temperature for a

quarter to half an hour. This method is quick in application, certain in its results, easy to work, and not liable to derangement, and for these reasons is to be strongly recommended.

It should be noted that saturated and not superheated steam should always be employed, because the former is more efficient and rapid in its working, and penetrates more readily into bulky articles than superheated steam, which practically acts like a gas. Again, the use of superheated steam involves a longer exposure of the articles in the disinfecting-chamber, a greater expenditure of fuel, and an increased liability to damage in the case of delicate materials.

REQUIREMENTS OF A DISINFECTING-STATION.

1. Whatever apparatus be employed, satisfactory provision must be made to insure that infected articles are not allowed to become too wet, or otherwise the colours will run; the disinfected articles should also be fairly dry when removed.
2. The steam used for disinfection must be 'air-free'; in other words, the air in the chamber must be withdrawn by some mechanism before the steam is admitted, as steam mixed with air is not nearly so efficient or reliable, from a sterilizing point of view, as 'live steam,' the sterilizing properties of which are experimentally well known.
3. The apparatus must not be too expensive, either as to cost, upkeep, or working. It should be simply devised, and not require skilled or expensive labour for its manipulation.

All the above requirements are met by the Washington-Lyon patents, under which the most efficient and modern

sterilizers are built. The apparatus manufactured by Goddard, Massey, and Warner, of Nottingham, is perhaps the best and most practical. The apparatus consists of a large rectangular 'tubular' galvanized iron chamber. This latter is steam-jacketed and provided at each end with a steam-jacketed door, which can be securely fixed and bolted. The lower part of the steam-jacket represents the boiler, underneath which the fire is placed. Steam is first raised in the jacket until a pressure of 20 pounds per square inch is reached, the excess of steam blowing off by a safety-valve. The articles are now placed in a cage or receptacle which fits into the rectangular chamber, and the doors are shut and secured. By means of a steam-jet a stream of hot air is now drawn through the chamber for a couple of minutes. The steam is then turned on and allowed to fill the chamber until a 20-pound pressure is reached. At this temperature the articles remain twenty minutes. The steam is then allowed to escape, and hot air is again drawn through the chamber by the same method in order to thoroughly dry the articles. The door is then opened and the articles removed.

APPENDIX XVIII (*a*)

Showing the Manner in which the Sputum is collected at Various Sanatoria

Method.	Names of Sanatoria.
Paper cups (pasteboard, etc.)	Adirondack, Sharon, Chestnut Hill, Glockner, Colorado, Chico Springs.
Various patterns of pocket-flask	Mundesley, Alland, Dr. Römpler's, Falkenstein, Laubbach, Nordrach Colonie, Ruppertshain, Reknaes, Lindheim, Alexander, Leysin, Montana, Basel, Rossclare, Vale of Clwyd, Guimar, S. des Pins, Nordrach in Wales, Nordrach on Dee, Holne Chase, Dunstone Park, Consumption Sanatoria, Scotland, Chico Springs, Moorcote, Davos (Dutch), Dr. Weicker's, Canigou, Dr. Turban's, Winyah, Rostrevor, Felixstift, Crooksbury, Friedrichsheim, Oderberg.

In addition to the above, handkerchiefs are used merely for wiping the mouth ; these may be—

Ordinary handkerchiefs or scraps of linen, as at—	White Gables, Rostrevor, Loslau, Nordrach Colonie, Grampian, and Crooksbury.
Or Japanese handkerchiefs, as at—	Adirondack (napkins), Dunstone Park, Sharon (rubber pouches), Guimar, Holne Chase.

The use of spit-cups in the bedrooms is, in the majority of cases, combined with pocket-flasks. At Whitehaven Sanatorium, U.S.A., an excellent arrangement is employed which consists of a tin cup with sliding bottom and lined with waterproof paper. Basins fixed to walls and flushed like urinals are used at Loslau. Fixed spittoons, especially

when on the ground, are open to several objections, as many patients are not sufficiently expert in their use. Spit-cups should not be of glass or porcelain, as these readily break, and several instances in which inoculation has occurred in this way have been recorded. Porcelain is also liable to crack in the frost.

APPENDIX XVIII (*b*)

Showing the Fluid used in Receptacles for Sputum at Twenty-nine Sanatoria

Fluid.	Names of Sanatoria.
Water	Las Vegas, Dr. Römpler's, Dr. Driver's, Laubbach, Schömberg, Alexander, Loslau, Ventnor.
Corrosive sublimate	Chestnut Hill, Hygeia.
Lysol	Falkenstein, Hohenhonnef (lysol 1 per cent. and soft soap 5 per cent.), Dr. Weicker's, Altena, Braunwald, Dr. Sanders'.
Carbolic acid (5 per cent. to 20 per cent.)	Victoria Hospital, (Edinburgh), Overton Hall, Quisisana, Moorcote, Consumption Sanatoria of Scotland, Dunstone Park, Nordrach on Dee, Nordrach in Wales, Montefiore Home, Durham.
Formalin ...	Grampian.
Carbonate of soda	S. des Pins.
Chloride of lime	Whitehaven.

APPENDIX XVIII (*c*)

SHOWING THE WAY IN WHICH THE SPUTUM IS DEALT WITH AT SIXTY-FIVE SANATORIA

Method.	No. of Sanatoria.	Names of Sanatoria.
Burnt without other treatment	25	Mundesley, Adirondack, Sharon, Chestnut Hill, Winyah, Glockner, Colorado, Hygeia, Alland, Loomis, National Ireland, Whitehaven, Ruppertshain, Krailling, Tonsaasen, Laurentian, Rostrevor, Rudgwick, Moorcote, Chico Springs, Sülzhayn, Guimar, Sanatoria for Consumption Scotland, Grampian, Belzig.
Burnt after being mixed with—	11	
(*a*) Peat mould		Alland, Oderberg, and Ruppertshain.
(*b*) Sawdust		Canigou, Rossclare, Linford, Vale of Clwyd, Nordrach Colonie, Cotswold, Crooksbury.
(*c*) Ferrous sulphate		Tonsaasen.
Boiling	3	Malchow (with soda), S. des Pins (mixed with a concentrated solution of carbonate of soda, boiled for forty minutes, and then poured into tank with sulphate of iron and lime), London Open-air (kept in tank into which steam is passed when laundry is in use).
Poured into w.c. or sinks	17	Dr. Driver's, Dr. Michaeli's, Hohenhonnef, Laubbach, Grabowsee, Albertsberg, Rehburg, Arlen, Reknaes, Ventnor, Victoria (Edinburgh), Lindheim, Quisisana, Dr. Turban's, Dutch Davos, Trespoey, Waldhof-Elgershausen.

Method.	No. of Sanatoria.	Names of Sanatoria.
Poured into w.c. or sinks after previous treatment[1] by—	4	
(*a*) Boiling		Reknaes, Trespoey, Halila (boiled with sublimate).
(*b*) Ferrous sulphate		Lindheim.
Treated with lysol	4	Altena, Braunwald, Dr. Weicker's, Dr. Sanders'.

At Nordrach on Mendip the sputum is placed in the septic tank.

[1] Apart from any antiseptic which may be used in the flask.

APPENDIX XVIII (*d*)

GIVING EXAMPLES OF THE MANNER IN WHICH THE RECEPTACLE FOR THE SPUTUM IS TREATED AT TWENTY-EIGHT SANATORIA

Method.	No. of Sanatoria.	Names of Sanatoria.
Burnt	7	Adirondack, Glockner, Whitehaven, Sharon, Chestnut Hill, Chico Springs, Colorado.
Boiled or subjected to steam	7	Montana, Moorcote, Canigou, Oderberg and Glückauf, Hauteville, Boserup.
Boiled with bicarbonate of soda	3	Las Vegas, Linford, and Nordrach Colonie.
Cleansed with various antiseptics	10	The Home at Denver (sublimate), Königsberg (sublimate), Dr. Turban's (sublimate and sodium chloride), Leysin (lysol and sublimate), Chestnut Hill and White Gables (porcelain cups for paper receptacle treated with carbolic), Whitehaven (tin cup for paper receptacles treated with carbolic), Falkenstein (lysol), Hohenhonnef (lysol), and Leysin (carbolic).

In many, as at the London Open-air Sanatorium, the receptacles are merely washed out with water.

APPENDIX XVIII (*e*)

SHOWING THE WAY IN WHICH THE ROOMS ARE DISINFECTED AT VARIOUS SANATORIA

Method.	Names of Sanatoria.
Moist cleaning is used in nearly all, as at—	Dr. Michaeli's, Albertsberg, Dr. Turban's (soap and water), Basel (soap and water), Waldhof-Elgershausen, Loslau, Nordrach Colonie, Oderberg and Glückauf, Recknaes, Moorcote, Grampian, Rostrevor, New Davos, Overton Hall, Laurentian, Rehburg, Durham County, Nordrach on Mendip, Halila, Hohenhonnef, Whitehaven, Inglewood, Vale of Clwyd, Montefiore Home, Consumption Sanatoria of Scotland, Nordrach in Wales, Adirondack (soap and water), Rossclare (soap and water), Boserup (soap and water).
In many, various disinfectants are used in addition, for disinfecting the walls, floors, and furniture	
1. Corrosive sublimate	Trespoey (spray), Lindheim, Quisisana, Braunwald, Chico Springs, Linford, S. des Pins, Nordrach Colonie (from time to time).
2. Carbolic acid ...	Rudgwick, Dunstone Park, Holne Chase, Adirondack (from time to time).
3. Lysol	Grabowsee, Malchow.
4. Chloride of lime	Sharon.
5. Soda solution ...	Davos (Dutch).
6. Sulphur... ...	Rudgwick, Rossclare.
7. Bread to walls, etc. (afterwards burnt)	Hohenhonnef, Laubbach, Arlen, Lindheim, and Tonsaasen.
8. Creolin	Crooksbury and Schömberg.

Method.	Names of Sanatoria.
9. Various preparations of formalin (when patient leaves the sanatorium)	Mundesley, Chestnut Hill, Winyah, Hygeia, Glockner, Chico Springs, Trespoey, Canigou, Adirondack, The Home at Denver, Las Vegas, Alland, Dr. Römpler's, Dunstone Park, S. des Pins, Falkenstein, Dr. Weicker's, Schömberg, Davos (New), Davos (Dutch), Grampian, Beauregard, Montana, Crooksbury, and Basel.

At most sanatoria the rooms are periodically fumigated, repapered or revarnished, etc., as an additional precautionary measure.

APPENDIX XVIII (*f*)

Showing the Way in which the Linen and Bedding are disinfected at Various Sanatoria

Linen.

Method.	No. of Sanatoria.	Names of Sanatoria.
Boiled ...	24	Sharon, Winyah, Dr. Michaeli's, Laubbach, Waldhof-Elgershausen, Nordrach Colonie, White Gables, Loslau (after soaking in lysol), Malchow, Albertsberg, Oderberg and Glückauf, Lindheim, Dr. Turban's, Montana, Rudgwick, Crooksbury, Adirondack, Dr. Weicker's, Moorcote, Nordrach in Wales, Braunwald, Whitehaven, Chestnut Hill.
Boiled with sodium bicarbonate	5	Braunwald, Canigou, Loslau, Sülzhayn, Laurentian (also treated with formalin).
Steamed ...	24	Hygeia, The Home at Denver, Las Vegas, White Gables, Arlen, Davos (Dutch), Alland, Canigou, Trespoey, Dr. Römpler's, Reknaes, Belzig, Dr. Driver's, Dr. Michaeli's, Falkenstein, Hohenhonnef, Quisisana, Nordrach on Dee, Schömberg, Grabowsee, Halila, Ruppertshain, Alexander, Basel.
Treated with hot air	1	Montefiore Home.

At Nordrach in Wales specially soiled linen—*e.g.*, by upsetting of spittoons—is allowed to soak in a disinfectant and then burnt.

Bedding.

Method.	No. of Sanatoria.	Names of Sanatoria.
Treated with hot air ...	3	The Home at Denver, Reknaes, Montefiore Home.
Steamed	5	Falkenstein, Rehburg, Montana, Dr. Michaeli's (Basel).
Treated with corrosive sublimate and soda	1	Tonsaasen.

APPENDIX XVIII (g)

SHOWING THE WAY IN WHICH THE CROCKERY AND SILVER (FORKS, ETC.) ARE DISINFECTED AT TWENTY-SIX SANATORIA.

Method.	Names of Sanatoria.
Boiling	Winyah, Beauregard, Oderberg and Glückauf, Nordrach in Wales, Waldhof-Elgershausen (sterilizing apparatus), Adirondack, Falkenstein, Cotswold, Crooksbury, Moorcote, Rudgwick, Loomis, Basel, Belzig.
Boiling with soda	Braunwald, Grampian (also antiseptic soap), S. des Pins, Canigou, Reknaes, Loslau, Rossclare, Rostrevor.
Treated with corrosive sublimate	Beauregard (glasses only).

At the Consumption Sanatoria for Scotland the patients wash their own glasses, whilst at Dunstone Park laryngeal cases have special glasses.

APPENDIX XVIII (*h*)

Showing the Precautions with Regard to the Use of Milk which are taken at Various Sanatoria

A pure milk may be obtained by—

1. Efficient veterinary supervision, as at Moorcote, Sanatorium des Pins, Rudgwick, and the Grampians.
2. Tuberculinization of cows, as at Hohenhonnef, Cotswold, Falkenstein, Nordrach on Dee, Sanatorium des Pins, Rostrevor.
3. Sterilization by means of heat, as at Rupperts-hain, Rossclare, Reknaes, Dunstone Park, Holne Chase, Loslau, Belzig, Nordrach on Mendip, and Crooksbury.

APPENDIX XIX

A Specification of the Sanitary Arrangements in Proposed Scheme

This specification is drawn up on the idea that the drainage of the proposed sanatorium will be discharged into an ordinary sewer in the main road (with proper intercepting trap and inspection chamber). If such a sewer, however, is not available, the sewage will be discharged into a septic 'tank,' constructed on the principle of the Septic Tank Syndicate. In this latter case the bathroom, housemaid's, and other slops will be taken by a separate system of drains, provided that Kenwood's system of irrigation is adopted.

The water-supply for cooking and drinking purposes to be

quite separate and distinct from all water-closet or similar supply.

The sanitary arrangements in each tower to be on the most approved system, so as to allow the complete removal of all excreta and all liquid refuse, all fittings being properly trapped to avoid the entrance of sewer-gas into the building, but without interfering with the free passage of a current of fresh air through all soil and waste pipes.

Water-Closets.—The water-closets' apparatus will be of an improved 'wash-out' type or a 'valve closet,' with the traps connected by branches into a main stack of heavy lead soil-pipes, which at the foot will join the iron (or glazed stoneware) drain. The apparatus will be flushed with 3 gallons of water after each use from a water waste-preventing cistern fixed 6 feet above the seat. The soil-pipe will also be carried up above the level of the flat roofs as a ventilating shaft, to allow of a free passage of air to a sufficient height to prevent any escaping sewer-gas becoming a nuisance to anyone on the roof. Proper 2-inch lead anti-syphonage pipes will be taken from the back of each trap to prevent the water-seal in the trap being disturbed by the suction of air when other apparatus is in use, and will also be carried up well above the roofs.

Sinks.—The housemaid's sinks will be of an improved type of glazed stoneware, having special provision for thoroughly cleaning bed-pans, etc., together with accommodation for general washing up. They will be trapped and connected by branches into a main stack of heavy lead soil-pipes in a similar manner to the water-closets, will join the iron (or stoneware) drain at foot, and be carried up as a ventilator above the level of the flats. They will also have anti-syphonage pipes.

Baths.—Each floor of the sanitary tower to have a

Doulton's vitreous enamel bath, together with shower-baths (the number of these varying with the individual blocks), trapped, drained, and ventilated as described for sinks. The pipes for these will discharge over an open length of channel, terminating in a gully, and will not be connected direct to the drains, thus preventing all possibility of sewer-gas entering the pipes. The joints in the waste-pipes to be formed with indiarubber expansion rings, to allow of the expansion and contraction of the lead pipe.

The *tile floors* of the shower-bath rooms will be given a slight fall to a trap and waste in the floor, connected into the bath waste with proper ventilation.

Lavatory.—The lavatories will be of white glazed stone-ware. They will be trapped, drained, and ventilated in a similar manner to the baths.

Kitchen and Scullery Sinks.—Special provision will be made for the removal of all grease and other matter by the adoption of proper grease-traps having a periodical flush from automatic flushing-tanks.

The Drainage.—The soil-pipes and gullies will be connected to heavy iron drain-pipes, treated internally with Dr. Angus Smith's solution and laid on a bed of cement concrete, the whole laid in straight courses with even falls, and having proper inspection chambers at every change of direction or at points of junction. The walls of the chambers will be built in brickwork in cement, and properly rendered in cement; the bottom will be formed with half-channel pipes, and the tops finished with galvanized-iron manhole covers and frames. *Fresh-air inlets* will be supplied to the drains so as to produce a constant current of fresh air passing through and up the soil-pipes. *Suitable automatic flushing-tanks* will be fixed in proper positions to cleanse and disinfect soil-pipes, wastes, and drains.

APPENDIX XIX (*a*)

The Method of Dealing with the Disposal of Sewage when the Water-Carriage System is not available and Conservancy Methods are not used

The Rivers Pollution Prevention Act makes it illegal to discharge sewage direct into a stream, hence the sewage must be purified. This may be accomplished by

(*a*) The biological method.
(*b*) Subsidence.
(*c*) Straining.
(*d*) Precipitation.

(*a*) *The septic-tank system or biological method* of sewage treatment has for its object the purification of sewage by natural means and the avoidance of the cost entailed by artificial treatment. The process adopted may be briefly described under two heads. First, the destruction of the solid matters as such, and, secondly, the purification of the dissolved polluting matters. The former is brought about in a receptacle called the septic tank, which consists of a chamber containing about one day's flow of sewage, more or less according to the strength of the latter. It is generally covered, and the exclusion of air is completed by the submergence of the inlet and outlet pipes, so as to deliver and draw off respectively below the surface of the sewage. Instead of filling and emptying the tank alternately, as is done with a precipitation-tank, the sewage is allowed to run through it continuously, and it is not emptied from one year's end to another. Although the flow through the tank is continuous, the motion is so slow that its contents are practically at rest. In this way

ample opportunity is afforded for the separation of the solid matter, the heavier substances sinking to the bottom, while lighter bodies float to the surface. Seeing that all these are encouraged to enter the tank instead of being kept back by screens, as is done where precipitation is resorted to, a thick scum soon forms over the surface of the liquid. Various races of liquefying bacteria, known as 'anaerobic,' are thus afforded the conditions most favourable to their growth and activity—viz., an abundant food-supply, darkness, an equable temperature, absence of atmospheric oxygen, and a steady current to wash away the products of decomposition. So well do they do their work that tanks have been in use for close on four years without requiring to be cleaned. The floor of the tank is covered with a fine deposit, largely mineral; but the bulk of this is trifling compared with that of the solid matter which has been brought in with the sewage. The second process—viz., purifying the liquid effluent—is, like the preliminary liquefaction, performed by bacteria. These, however, are aerobic. They are accordingly housed in a very different fashion, their workshops being known as the 'filters.' A plentiful supply of oxygen is essential to the purification of the effluent. The dark-coloured fluid which escapes at the further end of the tank over a weir, is therefore discharged into a series of large traps, or aerators, as they are called, which mechanically cause the water to entangle or dissolve large quantities of air.

The aerated effluent now passes on to a filter charged with some granular material, such as coke, burnt ballast, or broken clinker, the interstices of the material being filled with the liquid to be purified. The filter is kept full for a certain period, and the contents are finally drawn off. The liquid descending through the filter is brought into close contact and thoroughly mixed with the air

which the latter contains, and is purified by the agency of the aerobic bacteria. In addition to promoting the admixture of liquid and air, the filtering material serves the further important purpose of affording a resting-place for the bacteria, which would otherwise be washed out at every discharge. To secure the utmost efficiency, these organisms must be brought as near their work as possible; in other words, the interstices should be narrow, so that no portion of the liquid may be far from the filtering medium. The latter should be in small pieces, so as to afford the maximum superficial area; but, on the other hand, it should not be so fine as to prevent the liquid from passing away freely. In order to secure efficient working, and at the same time to maintain the filters in a proper condition, they must be employed in regular rotation. For this purpose an automatic alternating gear is introduced in which the various stages of filling, resting when full, discharging, and aerating, are brought about in turn by means of an overflow from the filter last filled. The whole installation is thus rendered completely automatic, the attention required being reduced to an occasional visit of inspection, oiling the bearings of the gear at long intervals, and throwing the spare filter into work, in place of one of the others, every second or third day.

Speaking generally, the complex organic substances present in the crude liquid are broken down in the septic tank into simple forms, of which ammonia, carbonic acid gas, nitrogen, hydrogen, and marsh gas may be mentioned. Most of these pass off as gas, but the ammonia which is dissolved in the tank effluent requires further treatment by oxidation. This is accomplished in two stages, the first producing nitrous acid, and the second resulting in the formation of nitric acid. The nitric acid attacks the alkalies present, and appears in the filtrate as nitrate of

soda or nitrate of calcium. Thus, the nitrogenous matters to which the sewage chiefly owes its offensive character are finally converted into harmless salts which cannot pollute a river or give rise to secondary decomposition.

The possibilities opened up by the bacterial methods of purification have led to the introduction of new standards, to which a final effluent is called upon to conform. Formerly all that was required of an effluent was that the impurity which it contained should be brought within certain prescribed limits, in order that it should not greatly pollute the river into which it was discharged. Nowadays it is not enough that the effluent shall not pollute the stream which receives it; it is expected to be capable of purifying the latter. As the effluent from the tanks is practically free from solids in suspension, it is in the best condition for either irrigation or filtration.

The biological method of dealing with sewage is undoubtedly the most scientific and the most practical of those in use at the present time. As, however, other methods are employed at certain sanatoria, we give a brief description of them.

(*b*) *Subsidence.*—The crude sewage is allowed to settle in large tanks; the suspended matter falls to the bottom, and a clear supernatant fluid results, which is decanted off. At the best this is an obsolete and slow process, as it demands the use of large tanks, which involve great expenditure in their construction and a considerable amount of land.

(*c*) *Straining.*—Attempts have been made from time to time to purify sewage by straining off its solid ingredients through beds or filters of gravel, ashes, or charcoal. The frequent choking of the filters involves their continuous renewal at great cost. Again, the fact that the sewage so

treated is merely clarified, and is not deprived of its soluble polluting ingredients, at once stamps this method as being inadequate.

(*d*) *Precipitation.*—Many years ago it was recognised that the addition of certain chemical substances to sewage prior to its entering the settling tanks caused a rapid and copious precipitation of its suspended matters. The knowledge of this fact led to many experiments with a large number of different chemical materials. After a prolonged practical trial, it is now known for certain that most of these methods are worse than useless, partly because they are very expensive, and partly because they render the deposit or 'sludge' valueless for manurial purposes, or lead to no appreciably beneficial result. At the present moment, lime, sulphate of alumina, and proto-sulphate of iron are the only substances which can be regarded as being fairly efficient precipitating agents in the purification of sewage. *Lime* chiefly induces precipitation by forming insoluble calcium carbonate with the free carbonic dioxide in the water. With the precipitation of this substance most of the suspended organic matter of the sewage is carried down, and so forms the sludge or deposit at the bottom of the tank. It is well to recollect, however, that if too much lime is used it dissolves a considerable quantity of the offensive matter previously in suspension, and the effluent is thus rendered fouler and stronger than ever. *Sulphate of alumina* brings about precipitation by virtue of its formation, with the lime or calcium carbonate in the alkaline sewage, of calcium sulphate, the alkaline sewage being precipitated in the form of a flocculent material which carries down certain suspended organic matters. Sewage treated in this manner is less prone to induce decomposition, and so in this important respect aluminium sulphate is superior to lime as a precipitating

agent. The drawback, however, to sulphate of alumina is the fact that the effluent is acid and harmful to vegetation, and so cannot be used as an irrigation fluid. This objection is somewhat modified by the admixture of lime with the alumina, in the proportion, approximately, of about 5 grains of each to the gallon of sewage, as in this way a neutral sludge is obtained. *Iron protosulphate* is but little used nowadays as a precipitating agent. It has the insuperable objection of staining the mud banks of the stream, into which the effluent is discharged, a dirty brown colour, due, of course, to the formation of sulphide of iron, and this in the eyes of the uninitiated public renders its use impracticable. However, the combination of iron with sulphate of alumina enters into the composition of several well-known precipitating agents—notably the ferrozone and the alumino-ferric processes. Occasionally, substances which act as deodorizers or antiseptics are added to sewage in addition to chemical precipitation ; for example, the addition of manganate of soda and sulphuric acid to chemically treated sewage was the original method devised by Dibdin, the chemist to the late Metropolitan Board of Works.

APPENDIX XIX (*b*)

On the Disposal of Slop Waters

Definition.—Slop waters consist for the most part of kitchen sink wastes, highly charged with foul decomposing organic matters, and of house slops or urine, soapsuds, grease and dirt, together with rain and surface drainings.

Methods of Disposal.

1. They may be *stored up in impermeable cement cesspools*, and used for garden purposes by means of pump,

hose, and jet. This method should not be employed in places where economy in water is not necessary, as the storage of foul waters in any form cannot be recommended.

2. They may be passed through a *small coke or ash filter*, erected some distance from the house. The disadvantages of these filters are the constant attention they require, the ease with which they become choked up and rendered temporarily ineffectual, and the nuisance which may arise from them.

3. They may be disposed of by *sub-irrigation*. This, from a practical point of view, is the best and most efficient method. The drain conveying the slop waters from the house is connected, by a few lengths of impermeable piping, to a system of 2-inch agricultural, porous pipes, laid 5 feet apart, about 12 inches deep in the soil, and having a fall of from 6 to 8 inches per 100 feet. The ends of the pipes rest on cradles formed of half-pipes, and similar covers should be placed above, so as to effectually prevent earth getting into the pipes and choking them. There must be an air-vent at the lower end of the main outlet pipe to allow air to escape. A flush-tank, discharging at intervals, should be fitted to the top of the system, to prevent earth getting into the pipes and forming a deposit. The system advocated by Kenwood is the best. No mechanical cleaning of the pipes is necessary, as a siphon tank flush, discharging water at definite intervals from the head of the system, effectually provides a mechanical cleansing of the pipes. This system requires a spare field,

preferably on an incline, and, once the pipes have been properly laid and fitted, gives but little trouble.

APPENDIX XX

On the Requirements for Meteorological Research

Standard instruments fitted in a proper Stephenson's screen should be provided. In order to obtain accurate reading, this screen should be placed at a distance from all walls and trees, and at least 4 feet above the ground. Inside the screen should be fitted a maximum mercurial thermometer, a minimum spirit thermometer, a dry and wet bulb thermometer, a registering thermograph (Richard Frères), and a registering barograph. A solar radiator thermometer should be placed, on the roof of the screen, in a position freely exposed to sun and air, its bulb being directed towards the south-east.

An accurate Negretti and Zambra's Universal Sunshine Recorder, which possesses adjustments for any latitude, should be placed in an adjoining situation, care being taken that it is exposed to the rays of the sun in all directions. A minimum and terrestrial radiator thermometer should be placed on the grass close to the screen, and the grass in the vicinity kept closely cut. Further, a registering rain-gauge which records the amount and time of rainfall on a revolving drum, should be placed somewhere in the neighbourhood of the house, but in such a position that it is not sheltered in any direction.

A Robinson's recording anemometer, which registers the velocity of the wind, by means of a long shaft, in the quarters of the medical men below, should be placed on

the top of the administration block, preferably in as elevated and unprotected a position as possible. A Forten's barometer should also be fitted in the same situation.

All observations should be taken and entered in a book, specially printed for the purpose, at definite hours, 8 a.m. and 6 p.m. being usually considered sufficient.

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