On the construction of operating theatres : with a description of the operating theatre of the new Glasgow Cancer Hospital / by George Thomas Beatson.

With the Author's Compts.

ON THE CONSTRUCTION

(2)

OF

OPERATING THEATRES,

WITH A

DESCRIPTION OF THE OPERATING THEATRE OF THE NEW GLASGOW CANCER HOSPITAL.

BY

GEORGE THOMAS BEATSON,

B.A. (CANTAB.), M.D. (EDIN.), F.F.P.S.G.,

SURGEON TO THE GLASGOW CANCER HOSPITAL; ASSISTANT SURGEON TO THE WESTERN INFIRMARY; AND FORMERLY EXAMINER IN SURGERY TO THE UNIVERSITY OF EDINBURGH.

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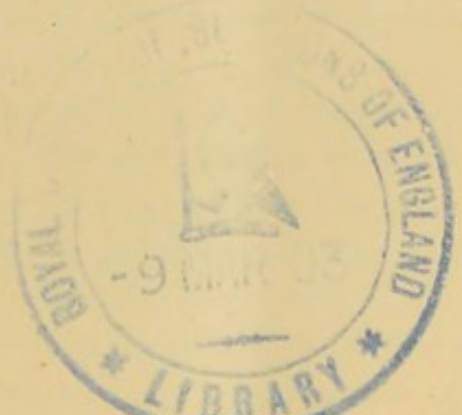

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ON OPERATING THEATRES.

If I was asked to say what is at present the most striking feature of modern antiseptic surgery, I would have no hesitation in replying that it is the great activity that is being shown in altering and rebuilding the operating theatres of our hospitals. I believe that in the whole history of these institutions there has never been such lavish expenditure as has been incurred during the last few years in the efforts that have been put forth by many of them to get thoroughly up-to-date aseptic operating rooms. Especially has this been the case when the hospital is a new one, and an opportunity has been afforded of embodying the most improved methods of construction and of internal equipment. Personally, I have been a good deal interested in this matter, as I had recently relegated to me, along with Mr. Andrew Myles, architect, the duty of the planning and furnishing of an operating theatre for the new Cancer Hospital that the citizens of Glasgow have seen fit to build for the reception and treatment of patients suffering from this disease in all its stages, operable or inoperable.

Agreeable as the duty was, I recognised that it had its responsibilities, for though I had a perfectly free hand in the suggestions I had to lay before the Directors, yet I felt that in the case of a public charity there should be no unnecessary expense incurred. On the other hand, I was very desirous that the hospital should have an operating theatre possessing not only all such admitted requisites as a good steady light and an abundant supply of hot and cold water, but so constructed as to allow of there being carried out in it the now recognised principles of modern antiseptic surgery.

It was in connection with this latter point that my chief difficulty arose, for there had to be decided at the very outset what were to be regarded as the best means for carrying out recent advances in surgery. As is well known, there is practically unanimity amongst surgeons on the point that suppuration, erysipelas, pyæmia and the other forms of blood poisoning that follow on wounds, whether accidental or made by the surgeon, are due to micro-organisms. Of this proposition there is absolute bacteriological proof, and it is in its turn supported by ample clinical evidence. When, however, we come to consider what is the best plan of excluding these septic organisms from wounds, we are at once face to face with a most varied "surgical ritual," the logical outcome no doubt of the recent advances in science, but marked in some cases by such elaborate details that the every-day routine of surgical procedure is made almost unworkable.

This elaboration of the precautions to be taken in surgical technique had its birth in Germany, but in America it has also taken root very widely, while of late it has infected many British surgeons, who now consider that it is absolutely necessary to adopt all the expensive arrangements that are required for carrying out what has come to be known as *aseptic surgery*. This term requires a word of explanation, and I think it is best described as *that method in surgical technique in which the use of antiseptics is as far as possible avoided during an operation*, their employment, indeed, being regarded as unnecessary, inasmuch as all the arrangements in the conduct and management of the operation are based on the principle of preventing any micro-organisms being present. Undoubtedly this is the highest ideal to aim at, and under it absolute success is ensured, but there is the very important question whether this success cannot be as well and as certainly obtained by other methods less expensive, less exacting, less responsible, and more workable. Anyone acquainted with the details of aseptic surgery as rigidly carried out by its disciples, and who has had experience of what have been very fairly described as the "uncomfortable extravagances" practised by its devotees, knows perfectly well that they are a serious drawback to the practice of the art of surgery, and that they should not be entertained unless absolutely necessary, in other words, unless it is impossible to obtain equally good results without them. To enable us to decide this question we must consider what is the

present state of our knowledge of the relations that micro-organisms bear to surgery. If we understand this we will be better able to express an opinion as to the weapons with which we should fight the foes and enemies of our wounds, deciding either in favour of the elaborate and expensive armament devised and "made in Germany," or standing by the simpler method of procedure that has received the title of "Listerian," in honour of him whose genius first shed light upon the obscure and mysterious subject of the infection of wounds.

One of the most important and radical changes that has taken place in our knowledge of the relationship of micro-organisms to surgical diseases has been our altered views on the influence of the surrounding air on "wound infection. Twenty-five years ago, when I had the privilege of working under Lord Lister, in the Edinburgh Royal Infirmary, at a time when antiseptic surgery was in its infancy, I well remember that if there was any article in the antiseptic creed we implicitly believed in it was that *the air was the source of wound infection, and that the active agents in it were the fungi that caused the ordinary processes of decomposition and putrefaction in all organic media.* I have lived to see this "atmospheric theory" abandoned, and Lord Lister himself admitting that it was erroneous. The evidence that has swept away this fallacy is twofold. In the first place, there is the bacteriological proof that the organisms which cause suppuration, erysipelas, and other forms of surgical blood-poisoning are of a *special kind*, and are not the ordinary fungi of putrefaction. In the second place, the air, when searched for these special organisms, was found not to contain them. In fact, it is very generally admitted that the air is the most unfavourable place for them, as they find in it neither the heat, moisture, nor nutriment that they need, and, indeed, some of them perish in its oxygen. Clinical experience further supports these facts. Many individual surgeons have found that their results under antiseptic surgery have been just as satisfactory in old buildings, with defective ventilation and apparently unsatisfactory atmospheric surroundings, as in the most recently constructed and equipped operating theatres. Personally, I can confirm this proposition, for during a period of two years I have operated in the small wards of our old cancer hospital with most excellent results, and with an almost entire absence of septic disease. It may be taken

then as granted that the air *per se* is not the source of wound infection.

Another equally accepted fact is that what I may term surgical bacteria have their habitat and breeding ground *in the dust and organic matter round us.* The surfaces of all substances exposed to the air are *possibly* covered with them, and hence our hands, though æsthetically clean, are surgically contaminated, as also are our clothing, surgical instruments, and, indeed, everything else upon which dust may settle. Now, it has been shown conclusively that it is by *actual contact* that wounds become infected, and when inflammation, suppuration, or any other "surgical disease" appears in a wound, we know that some organic material, carrying the micro-organisms of these diseases, has found access to it. In short, it has been in some way contaminated by contact with disease-producing dirt. This may be due in the case of an accident to whatever caused the injury, or it may have been subsequently introduced by hands, instruments, dressings, or by the patient's skin being surgically unclean.

With this knowledge of the part that dust plays in the conveyance of infection to wounds, we learn the general lesson that everything brought near a wound must be kept free of organic material with its possible accompanying micro-organisms, and that when dealing with wounds, be it by operation or otherwise, our procedures should be based on the principle of disturbing the dust as little as possible. Thus, it would be a very imprudent thing to clean and sweep out a room just previous to an operation, the effect of which would be to fill the atmosphere with dust, and though, as I have said, the air *per se* is not harmful, it may be rendered a source of danger by such a step, for, were the operation performed before all the particles had settled again, they might fall into the wound and do great mischief. For a similar reason all systems of ventilation that are accompanied by strong currents of air are harmful in operating rooms, as they lead to stirring and dissemination of the dust and its subsequent deposition on what is termed "the field of operation." On the same grounds, the most scrupulous care should be exercised in hospital wards in dealing with suppurating wounds to which dry dressings are applied. The discharges should not be allowed to drop on the floor of the wards or anywhere where they could harden and be disseminated as dust. Consequently, dry dressings that contain

pus should be at once placed in covered receptacles or saturated with moisture. *Micro-organisms cannot be given off into the air from moist surfaces.* This very important fact is one that should be constantly kept in mind, for it, and the other one already mentioned—viz., *the gravitating power of dust, if not disturbed by undue currents of air*—are largely made use of in the ordinary arrangements for carrying on a successful surgical technique.

There are other facts, too, in the life history of micro-organisms that bear upon surgical work. In the first place, they cannot grow and develop unless they have present the three following conditions :—(1) A suitable soil ; (2) moisture ; (3) heat. In the second place, we know that, having once come into existence, the withdrawal of these conditions will not in every case ensure their death. The reason for this is that some micro-organisms have the power of multiplying in a special way—that is, by the formation of small insignificant bead-like bodies called *spores*. The importance of this process lies in the fact that these *spores* are the most resistant kind of living matter that we are acquainted with. They will undergo the most severe ordeals of heat and cold, and yet retain their vitality. They resemble in this way the seeds of plants that have been known to exist for thousands of years as mere dried organic masses, yet, when put into the ground under favourable conditions, have grown and flourished, just as did the the grains of wheat found in the catacombs of Egypt. It will be readily understood that such tenacity of life might easily render these spores a source of danger in surgical work.

Fortunately we find that the *two species* of disease-producing organisms, which cause most frequent trouble in surgical cases, do not form spores. These two are known respectively as *streptococci* and *staphylococci*, the former being so named from their tendency to range themselves in chains, the latter from their grouping themselves in clusters like bunches of grapes. Neither of these multiply by spores, nor, as far as is known, does the bacillus of diphtheria. On the other hand, the micro-organisms, possibly, of tubercle (consumption), and certainly of malignant pustule (anthrax), and of lockjaw (tetanus), do, and consequently they have to be reckoned with in the steps that require to be taken to prevent every possible form of wound infection. What are these steps? The reply to this question necessitates a brief consideration of the means we possess for destroying micro-

organisms, and so rendering "sterile," as it is termed, everything (hands, dressings, and instruments) that has to be brought into contact with wounds.

Defining "sterilisation" as *the condition of complete freedom from micro-organisms*, it has been found that there are two methods by which this can be satisfatorily and reliably attained. These are—(1) By heat; (2) by chemical agents. *Heat* is the more potent of the two, and it may be employed in the form of (*a*) boiling water, (*b*) steam, and (*c*) hot air. These vary in their potency, and I have mentioned them in their order of merit, boiling water taking the first place. The *chemical agents* available are those substances termed antiseptics or germicides. They furnish a formidable list, the best known and most generally used being carbolic acid, corrosive sublimate, boracic acid, creolin, izal, and lysol. Of all our means of sterilisation, boiling water is, as I have said, far and away the most powerful. This is demonstrated by the fact that the *spores* of malignant pustule (anthrax) can be killed by it within very few minutes, while none of the *ordinary* solutions of any of the above mentioned antiseptics would do it at all probably. It could only be accomplished by the use for several hours of very concentrated solutions of them. But the fact is that, in surgical work, we have not to reckon so much, or, indeed, at all, with these spore-bearing micro-organisms, for those of tubercle, anthrax, and tetanus "are extremely rare in nature apart from patients who are actually suffering from the disease, and, on the other hand, the spores which may, and undoubtedly do, often enter wounds, belong to the class of saprophytic bacteria, and, unless under very special circumstances, are unable to develop in the wound or to cause any harm" (Watson-Cheyne). The most common surgical organisms we have to combat are non-spore-bearing, and they readily succumb in a few seconds to such solutions as 1 in 20 carbolic acid, or 1 to 1,000 corrosive sublimate. No doubt at times they envelop themselves in coverings of grease, blood, and pus, which render them more resistant to these antiseptic solutions, and consequently some modifications in dealing with them under certain conditions may be required, but the statement made above holds good as a general rule. This being so, it must be quite apparent that for simplicity and convenience the use of these antiseptic solutions connot be over-estimated in the conduct and management of our

operations, and that it is absurd to ignore them and to try to depreciate them by substituting for them more elaborate plans, which, no doubt, are quite reliable, but certainly are no better than those they would replace. Of course, all antiseptics require to be employed with caution when brought into contact with the tissues, as they are irritants to them, but any careful surgeon keeps that disadvantage always in view, and no longer deluges his wounds with strong lotions, and practically he finds that, if it should be necessary to apply to them any of the ordinary antiseptic solutions in use, no harm ensues, and the wounds heal kindly and well. This is a very important point, for German surgeons have largely advocated their aseptic system on the ground that it does away with the need of antiseptics during an operation, and so removes the harm these substances do to the tissues. The truth is that, judiciously applied, they do no real harm, and that it is quite unnecessary to set up an expensive and elaborate system of sterilisation to meet an imaginary evil.

From what has been said it will be quite apparent that, in the conduct of our operations, we must go on one of two principles—(1) Either make such arrangements that all micro-organisms will be entirely excluded, and consequently will not require to be destroyed, or (2) recognise the enormous difficulties attending their complete exclusion, and, while lessening in every way their admission, assume their presence, and, by a judicious use of antiseptics, prevent them coming in an active state into *contact* with the wound. The former is known as the German or aseptic, and the latter as the Listerian or antiseptic surgery. Of the respective merits of the two as regards the results obtained, they are on a perfect equality; but there cannot be a shadow of doubt that the Listerian plan is much simpler and more convenient. Surgery, when carried out on a rigid aseptic basis, is laborious, costly, and complicated in its arrangements. Further, it is not possible to put it into practice in a private house, and this is a serious drawback. On the other hand, Lister's simpler but equally safe technique can be practised anywhere, and to provide an operating theatre for it is not such a difficult task. In fact, there is no necessity for a great departure from the ordinary principles that have all along governed the building and furnishing of operating theatres. All that is needed in addition to these is the recognition of the recent advances that have been made in surgery, and

their embodiment in the plan of construction. Accordingly, what I aimed at in planning the operating theatre for the Glasgow Cancer Hospital was, not so much a bacteriological laboratory, as a room that would be simple in construction, well adapted for the work, a model of surgical cleanliness, and not too costly in price.

It may be as well that I now briefly touch upon the points that merit attention in connection with every operating room, and which I kept constantly before me, as neglect of them may seriously affect the usefulness and success of the structure.

1. *The Natural Lighting.*—This should be furnished not only by the windows, but also by a rooflight. For the windows, the aspect of the theatre should be *north*. From that direction we get the steady even light that the artist and the photographer prefer, whereas a *southern* aspect furnishes too direct and too powerful rays, which are a source of embarrassment to the spectators and also to the operator, partly by the glare rising in his eyes and partly by the tissues in the depth of the wound being thrown into shadow, especially if he tries to meet the difficulty by standing between the light and the part where he is working. A northern aspect, then, will alone furnish the good steady light required for an operating theatre, and the need for it is increased if there should happen to be no rooflight.

2. *The Size.*—Various circumstances must regulate this, the main one, of course, being whether medical students and practitioners are to have access to it when operations are being performed. If not, and only the operator, his assistants, and nurses have to be provided for, then no great dimensions are required, the chief point being that there should be room for all the necessary furnishings and a clear space for moving about in. If spectators are to be allowed, then there must be a corresponding provision in floor and cubic space for them. Of course, some surgeons make a great deal about the dangers that arise from having spectators present in the operating theatres, and various regulations are in force bearing on this point. By some they are denied entrance altogether, and by others they are admitted if clad in aseptic apparel specially provided. Others, again, require that they give an assurance that they have not recently been near any contagious disease, while some are only satisfied if they are shut off by a glass screen from the operation area. For my own part, I consider that too much has been made of this

question of spectators. I believe that when those actually engaged in the operation and who come into contact with the wound are careful to carry out all the necessary precautions that no harm can accrue from the presence of other persons in the vicinity. There can be no doubt that the utility of our hospitals as teachings centres will be impaired if students and practitioners are not to be permitted to be present at operations unless under conditions quite incompatible with their other duties. A system, too, of surgical technique that demands such a condition is also undoubtedly defective.

3. *The Floor, Walls, and Ceiling.*—Seeing that organic material when disseminated through the air in a dry state in the form of dust is the chief danger in operations, it is in this direction that our chief precautions must be taken, and the two principles to work upon are the ones I have already mentioned :—

1. The gravitating power of dust.

2. That micro-organisms cannot be given off into the air from moist surfaces.

1. *The Gravitating Power of Dust.*—This may be facilitated by the entire absence in the operating theatre of all ornate decoration, recesses, and corners. The walls should be free of ornamentation, and at their junction with the floor and ceiling they should be rounded off so that they should afford no lodgment for dust. In the same way any woodwork covering electric wires should be similarly shaped. Such an arrangement permits of the dust falling on to the floor, and of that thorough cleansing of the theatre which is such an important point to attend to.

2. *That Micro-Organisms cannot be given off from a moist surface.* —To allow of this principle being acted on it is essential that the floor, walls, and ceiling should be so constructed that water can be freely used upon them. This can only be done if they are composed of water-tight materials, and if proper drainage is provided.

(a) *Water-tight Materials.*—For the floor various substances have been employed. The following list includes the chief ones:— terazzo, tiles (of various kinds), glass, asphalt, cement, plaster of Paris soaked in oil, and linoleum. The general experience seems in favour of terazzo, which is composed of small marble blocks jointed with Portland cement and then polished. The objections urged against the others are that the tiles must have

grooves and joints between them and that it is difficult to get them of a material that will not stain; that glass is too slippery; that asphalt is too soft and absorbent; that cement is apt to crack; that the oiled plaster of Paris is not durable; and that the linoleum is only suitable for a small operating room and would not stand rough wear and tear. Favourable as has been the general verdict on terazzo, I confess I have never been enamoured of it. Its durability is, I think, over-estimated, and I know one operating theatre in Glasgow where it has already shown signs of giving way under a comparatively short period of wear and tear. Then the difficulty of getting skilled workmen to lay it down and its great expense are further disadvantages. Glazed tiles are what one would be inclined to select as the most suitable for the floor of an operating theatre, and I understand they can be made now to overlap so as to do away with joints between them, but, like glass, they are slippery, and the difficulty is to get them of any size, and, if unglazed, non-absorbable of blood, acids, and lotions. Some tiles submitted to me as perfectly non-absorbent did not stand the test of a mixture of blood and acid. This fact, together with their costliness, renders them, I think, not well suited for a floor. The material that I believe will be found more efficient than any other, and that possesses all the necessary requisites, is that known as *granolithic cement*, a combination of two parts of granite chips and one part Portland cement. It has the recommendation of being moderate in cost (being one-third the price of even cheap tiles), it has great durability, it has closeness of texture and is consequently quite water-tight, and it has no tendency, if properly laid, to crack. By the addition of a little oxide of iron a warm reddish colour may be imparted to it, and it does not show any stains conspicuously.

Just as a variety of substances have been used for the floor of operating theatres, so different materials have been employed for the walls and ceiling. Tiles, glass, marble, enamel varnish, and polished white cement have all been tried, while recently at Leeds I saw that the walls of their new operating theatres were being overlaid with a glazed substance called, I think, porcelline. Apart from the presence of joints, tiles and other inlaid substances like squares of glass do very well for walls, but they cannot be placed in the ceilings, and to my mind they cannot compare with the smooth even surface given by enamel varnish on a substance, like

adamant plaster, which can also be utilised for the ceiling. This adamant plaster takes a fine polish, is quite impervious to water, and is comparatively inexpensive.

(b) *The Necessary Drainage.*—This may be provided for by having the floor of the operating theatre sloping inwards to the centre, where an open grating is placed, or the floor may slope downwards to one end, where are placed outlets for any water and fluids. Personally, I think the floor sloping to one end is the best, for it is not good to have an open grating in the centre of the room—and possibly just under the operating table—as there may be a current of air conveyed by it. Whichever plan is followed, the outlet pipe should not open directly into the drains, but over an open grating. There should be no possibility of emanations from the drains entering the operating theatre.

4. *The Lavatory Arrangements.*—There should be in the operating theatre an abundant supply of hot and cold water. In addition, there should be a hose arrangement for the cleansing of the floor, walls, and ceiling, and suitable apparatus for the washing and sterilisation of the hands. This latter should be placed at one side of the room, and should have hot and cold water laid on to it. It may take the form of one of the various basins that have been devised, and there should be more than one of these. In connection with the basins, none of the plumber work should have any direct communication with the drains, and it should be reduced to a minimum. It should also be open and easily got at both for purposes of cleaning and repair. Simplicity in these matters is of prime importance, and I am not sure that such innovations as the treadle action for working by foot the water-cocks of the supply pipes of the wash-basins is of such great utility looking to the ease with which it goes wrong.

5. *The Ventilation, Warming, and Artificial Lighting.*—These are three important matters, but perhaps not quite so much so as in the case of rooms which are constantly occupied, and further, they have to be looked at from a different point of view.

Taking *ventilation* first, I believe that what I may term the natural plan by door, fireplace, and window, can be made to suffice without introducing any artificial method. All that is needed is a constant change and renewal of the air rendered impure by the respiration of those in the theatre. This should be accomplished without any draughts, for all perceptible currents

of air should be absent from an operating theatre, as they only tend to set in motion the dust, which, as we have seen, is a special source of danger in surgical work. As regards the air admitted by the open windows, we know that in cities it contains more micro-organisms than in the country, but that these are largely the spores of fungi, and that they even vary with the locality and the moisture of the atmosphere.

The subject of the *warming* of the operating theatre is one requiring careful consideration, as great injury to health may accrue to the patient from too low a temperature while undergoing a critical operation. For the purpose of heating, an open fire may be employed, the chimney in connection with it being useful for ventilating purposes. The drawbacks to the open fire are the necessity for the renewal of the combustible, the loss of heat up the chimney, the possibility of smoke coming into the room if the wind outside is high, and the difficulty of regulating the amount of heat. The same objections do not quite hold good in the case of a gas stove, and if any local means are employed this is probably as cleanly and efficient as any other. In every hospital, however, there is a system of collective heating either by hot air, hot water, or steam, and to each room a supply of heat is conveyed, there being an arrangement for regulating the amount entering the apartment. This collective heating should be utilised for the operating theatre. At the same time, it does not do to rely entirely on it, for systems of collective heating have an awkward way of going wrong, and the operative theatre might be rendered unavailable from such a cause just when most urgently needed. It is always advisable, then, to have in addition an open fire or some form of stove from which heat may radiate if required, hot water be obtained, or in which a cautery iron might be heated. There is no doubt that the results of heating in modern operating theatres are aided by the structure of the walls, which have no porosity and so prevent the loss of heat.

Liable as an operating theatre is to be used at any time, it must be well supplied by *artificial light*. Brightness, steadiness, and ease in manipulation are features that should be aimed at, and these are found in our ordinary gaslight, which, however, has the drawbacks of heating and contaminating the air of the room, and so being a source of oppression to any of its occupants. Hence it cannot bear comparison with the electric light, which

produces almost no heat, no soot, and no unhealthy gases of combustion, and in the form of the incandescent light is almost perfect. No doubt it is costly, but its advantages in the case of an operating theatre are well worth the additional outlay.

6. *The Furnishings*.—Under this heading must be considered not only the articles required in an operating theatre, but the material of which they should be made, for it is a *sine quâ non* that everything in an operating theatre should be able to bear washing with soap and hot soda solution, and not be injured by any amount of water thrown over them. Keeping these objects in view, the substances that have been selected for the manufacture of operating tables and other furnishings have been *steel* (nickel-plated), *brass* (lacquered and brass nickel-plated), and *iron* (white enamelled). The general opinion amongst instrument-makers is that iron is the most suitable material, and that white enamelled goods are the most satisfactory. Messrs. Down Brothers tell me that tables constructed of brass have a certain amount of spring, and are not so steady as those made of iron. Again, no matter what material is used, occasional touching up is necessary, and this is most easily accomplished with white enamelled goods. They also look best while in use. As far as possible they should be of metallic enamel, that is, they should have been passed through a furnace. Iron merely coated with white enamel paint does not wear well, and will not long resist soda and hot water if used for washing purposes. *Glass* has also been largely used in operating theatres for instrument tables, lotion trays, basins, bowls, and shelves. It looks well, shows at once any dirt or dust, but has the drawbacks of expense and brittleness. Experience shows that glass tables, lotion trays, bowls, shelves, and slabs are constantly being broken, and the replacing of them is a serious annual expense. In my opinion articles of white enamelled iron or porcelain are just as serviceable, can be as well cleaned, are not readily broken, and are much less expensive. Indeed, I should not be surprised if glass is not ere long quite superseded in the furnishings of an operating theatre because of its expense and brittleness.

7. *Accessory Rooms*.—If it can be conveniently arranged, an operating theatre should be kept for the actual performance of the operation, and there should be one or more accessory rooms for the preliminary preparations. If possible, there should be one

room immediately adjoining, where the patient can be brought and anæsthetised before being brought into the theatre. Especially is such a room necessary where the operation is performed in the presence of a number of spectators, as, for instance, a large class of students. The patient is thus saved the ordeal of witnessing the preparations made for the operation, and the still more painful trial, in the case of a sensitive delicate woman, of facing an audience, hushed and attentive it may be, but yet complete strangers.

Although it is necessary to have in the theatre sterilisers for hot water and another near the operating table for boiling instruments, and although any steam from them is not harmful, as the dampness induced is favourable to the laying of any dust, yet I think it preferable to have a separate room for the sterilising of any dressings or other articles, as by this arrangement there is no need to be occupying the theatre until shortly before the operation, and it can be left undisturbed from the evening before, thus giving any dust in it ample time to settle.

The Operating Theatre of the Glasgow Cancer Hospital.

I will now briefly describe this operating theatre, in the arrangement and construction of which the above principles had careful consideration. The *situation* chosen for it was on the upper floor of a new building that was erected between the hospital proper and the residence for the nurses. This arrangement placed it well away from the wards, thus avoiding all disturbance of the patients, and it furnished it not only with plenty of light from the sides and roof, but also with that *northern aspect* that is so desirable. In shape the theatre is almost square, being 22 feet in length, and 18 feet in width. The walls generally have a height of 12 feet, while in the centre of the roof is a large cupola for *lighting* purposes. In the walls are side lights furnished by four windows, one looking west and the other three north. These windows are 8 feet 4 inches in height, and 3 feet 6 inches in width, and they have a transom near the upper end dividing them into an upper smaller and a lower larger portion, both of which open on pivots (see Fig. No. 1). The *floor* is concrete, covered by a layer, 1½ inch thick, of granolithic, a mixture of Portland cement and ground granite. It is tinged a terra cotta colour,

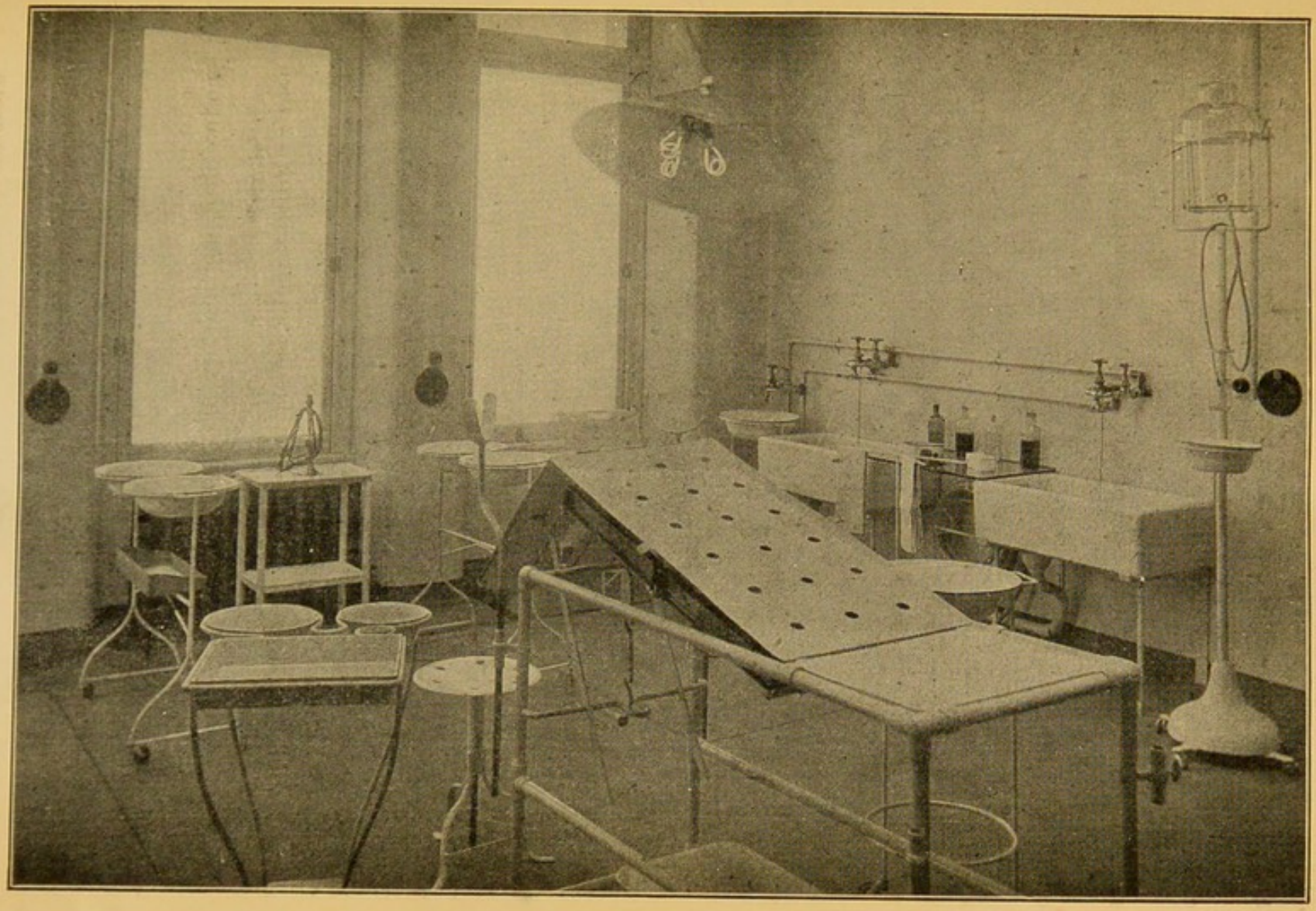

FIG. 1.

as less likely to show any blood stains, and as giving a warm appearance to the room. To allow of drainage the floor has a fall towards the northern end of about 6 inches, and it is furnished at intervals throughout its length and breadth by grooves which meet one another at right angles. At the lowest part of the floor is a gutter into which the longitudinal grooves enter. This gutter is in communication by two short channels with two gratings, each of which leads into an iron pipe which discharges itself outside over another open grating. In this way there is no actual communication between the air in the operating theatre and the drains of the hospital. I advocated this granolithic flooring as I was satisfied it would be quite as waterproof and non-absorbing as was needed for our purposes (and six months' use of it has confirmed this view), while it would be quite as durable as terazzo or tiles and would only be a third of the cost.

The *walls and ceiling* are of adamant plaster, covered with four coats of enamel paint. Adamant is a patent material which has been in use for several years, and has yielded very satisfactory results. It is more impervious to water than the ordinary cements. It may be smoothed and glazed by a facing of chromolith, but this is not really necessary, as with rubbing it takes on a fine polish, and when coated with several coats of enamel paint it is as non-porous as tiles, while, unlike them, it has no joints, and presents a smooth, glazed, uniform surface, that can at any time be easily brushed or washed down. In cost it is not one-fourth the price of tiles, and it is also very much cheaper than marble, porcelline, or any of the expensive cements. In addition, it had the further recommendation that it allowed of the thorough carrying out of the principle of there being in the walls and ceiling a complete absence of ornamentation, joints, recesses, or corners. In this way there are no obstacles to the thorough cleansing and sterilisation of the theatre.

For the *cleansing and disinfection of the hands* there are placed on the right side of the theatre, near the windows, two glazed enamel earthenware sinks, of the Dent & Hellyer pattern (see Fig. No. 2). The interval between them is bridged over by a glass slab, on which stand nail-brushes, soap, and the usual disinfectants for the hands. From each sink an outlet pipe is carried, and by their junction one single pipe is formed, which discharges its contents by an open mouth into the gutter at the

lowest end of the floor (see Fig. No. 2). Above each sink is a *junction-tap* for hot or cold water, or for both combined. The taps are placed some little distance above the sinks, so as to allow of the hands being washed beneath them, as there is no doubt that the correct way of washing the hands for sterilisation is in *running water*, and not in basins of water that at once become dirty. The sinks are furnished with chains and plugs, so that they can be filled with water if so desired, as they are large enough and deep enough to allow of the immersion of the hands, forearms, and elbows. The junction-taps here mentioned are in use in the Sick Children's Hospital in Edinburgh, and I have to thank my friend Mr. Harold Stiles for drawing my attention to their utility. For the cleansing of the theatre there is placed beside the hand sinks a separate junction-tap fitted for the attachment of a hose.

The *warming* of the theatre is accomplished by two radiators, which are of an American pattern, and are in connection with the collective system of heating by hot water which is in vogue in the hospital. By certain valves and stopcocks each radiator can be entirely shut off, if necessary, from this general system, or the amount of heat introduced regulated. In addition, there is an open fireplace on the left hand side (see Fig. No. 3), and in it has been placed a gas-stove, which can be used for heating purposes if required, and can also be made available otherwise. No special artificial systen of *ventilation* has been adopted. The so-called *natural plan* by the door, chimney, and windows, is the one relied on. By it the necessary renewal of the air in the room can be accomplished, and it creates none of those powerful, and, as we saw, harmful currents of air which should not find a place in an operating theatre, or even, for that matter, in a surgical ward. Although both parts of each window open, it is only the upper and smaller portions that are made use of, so as to avoid draughts; and with the view of minimising the currents of air entering by them, and of excluding, as much as possible, all organic material, they are protected on the outside by screens of fine gauze.

For *artificial lighting* the electric light is employed. It is furnished by a central electrolier of three lamps, each of 150 candle power. The electrolier hangs from the centre of the cupola (see Fig. 3), and can be moved up and down. The three lamps are under a large reflector, the angle of which can be

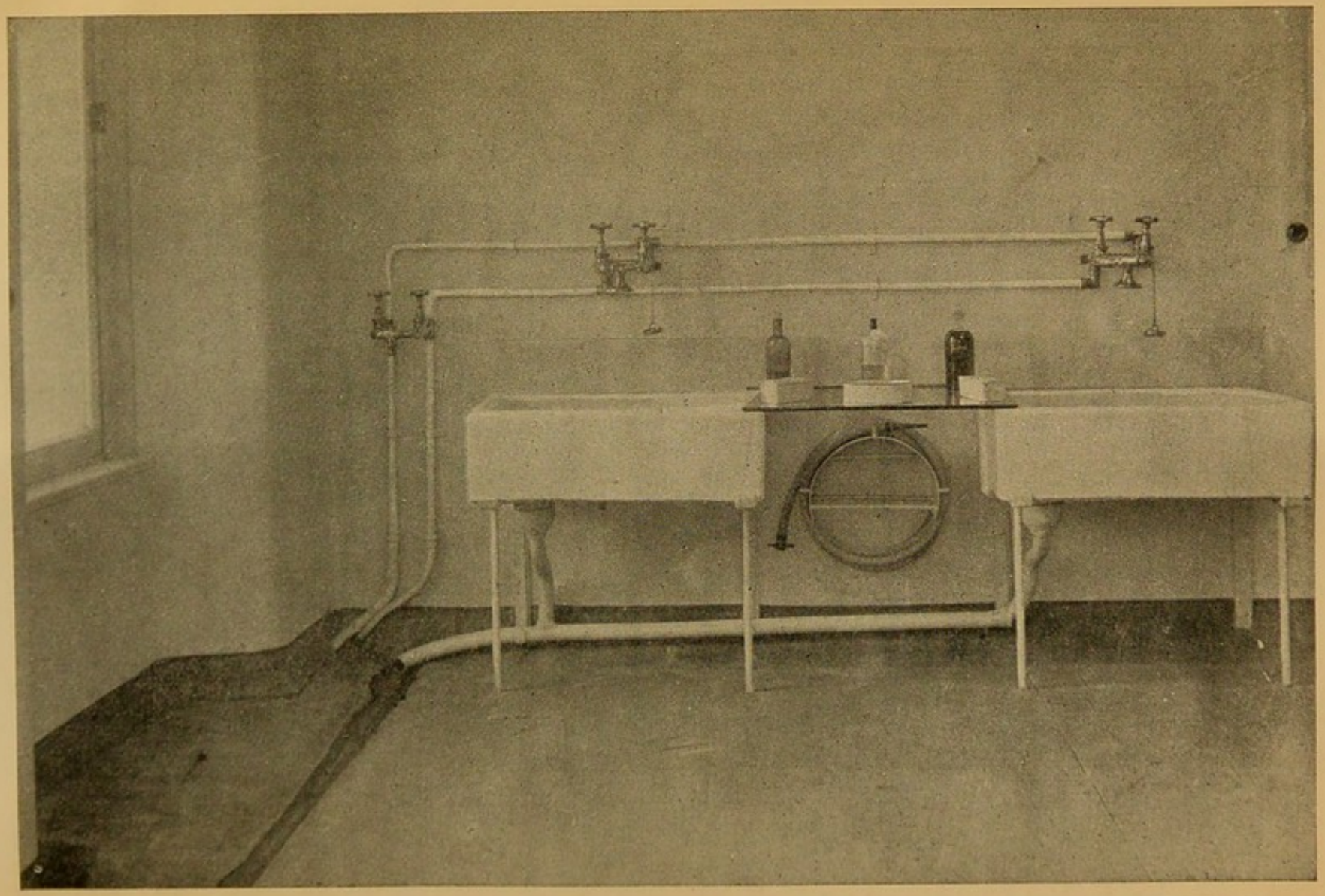

FIG. 2.

FIG. 3.

varied, while if a light is wanted low down, say on the operating table, there is a movable lamp which can be put in connection with the central electrolier by removing temporarily one of the lamps. In addition, at several points in the walls, plugs are provided for furnishing side lights if they are required. The question of having an apparatus stretching across the top of the the theatre, by which the central electrolier could be moved from side to side of the theatre, was considered, but not carried out, as it was thought that it would probably get out of order, and might possibly collect dust. As the operating table invariably stands in the centre of the theatre, the absence of such an apparatus is not felt very much, the attachable lamp being always available.

Two *accessory rooms* are attached to the theatre. One, a small one, contains a large steam steriliser for sterilising dressings, towels, sheets, and operating aprons. It is heated by gas, and has so far given every satisfaction. When the apparatus is opened to allow of the enclosed dressings being dried, an escape of steam takes place, and to get rid of this the room is provided with a special ventilating shaft surmounted by a Boyle's patent ventilator. In this room can also be stored dressings and other materials. The second room is larger than the other and is opposite to the theatre. Its walls and ceilings are of adamant plaster coated with enamel paint, but its floor is of polished pine. It is heated by a radiator, is also furnished with an open fire-place, and has in it the electric light. It is of such dimensions that two beds can be placed in it comfortably. It can be used for the administration of the anæsthetic previous to the operation, and for placing patients in it immediately afterwards, while, should the necessity arise, it can be made available as a second operating room.

The *furnishings* of the operating theatre are entirely of white enamelled iron, and were supplied by the Argyle Rubber Co., of 17 Renfield Street, Glasgow. This material was decided on when I found that my own personal experience of it, though limited, was confirmed by several of the leading instrument makers. It requires, no doubt, from time to time touching up, but so does every other material, while it has the recommendations of being moderate in cost and of looking well.

In drawing up the list of what was needed, I went on the principles that there should be nothing in the theatre save what

was needed for surgical purposes, and that the simpler everything was the better. The following articles were obtained :—

1. Operating table and stool with elevating screw.
2. Instrument cabinet.
3. Two instrument troughs or trollies.
4. Two instrument tables, 3 ft. and 1½ ft. long respectively.
5. Three double wash basins with movable basins.
6. Five single wash basins, four small and one large, with movable basins.
7. Three towel hangers.
8. A box for soiled dressings.
9. A glass irrigator on tripod stand, with small basin for holding the tubing and nozzle of irrigator.
10. Two sterilisers for water.
11. One large steriliser for towels, dressings, &c.
12. One steriliser for instruments.
13. One bandage and dressing box.
14. One bottle and dressing stand with shelves.
15. Six engraved glass reservoir jars for lotions, with glass stop-cocks.
16. One combination lotion trolly for the different things required for the sterilisation of the skin.
17. Four chairs.

A large number of the above articles, such as the tables and trollies for instruments and the wash-hand basins, are placed on the market made very much after one pattern, and there is no choice or selection as regards them. The only points stipulated about them were that they should be on rollers, and that the trays or troughs were to be of white enamelled iron and not of glass. So with the instrument tables. There were to be no glass shelves or tops for them. They were to be white enamelled iron all through, and on rollers. The article that called for the most consideration was the *operating table*. I confess I am not enamoured of any of the expensive and complicated tables that are at present in vogue, and the only three points that I laid down as essential for the table to possess were these :—(1) That it could be used in the Trendelenburg position ; (2) that it could be heated while in use ; and (3) that the cost should be moderate. The table furnished by the Argyle Rubber Co., of Glasgow, met all these requirements, and possesses in addition other good

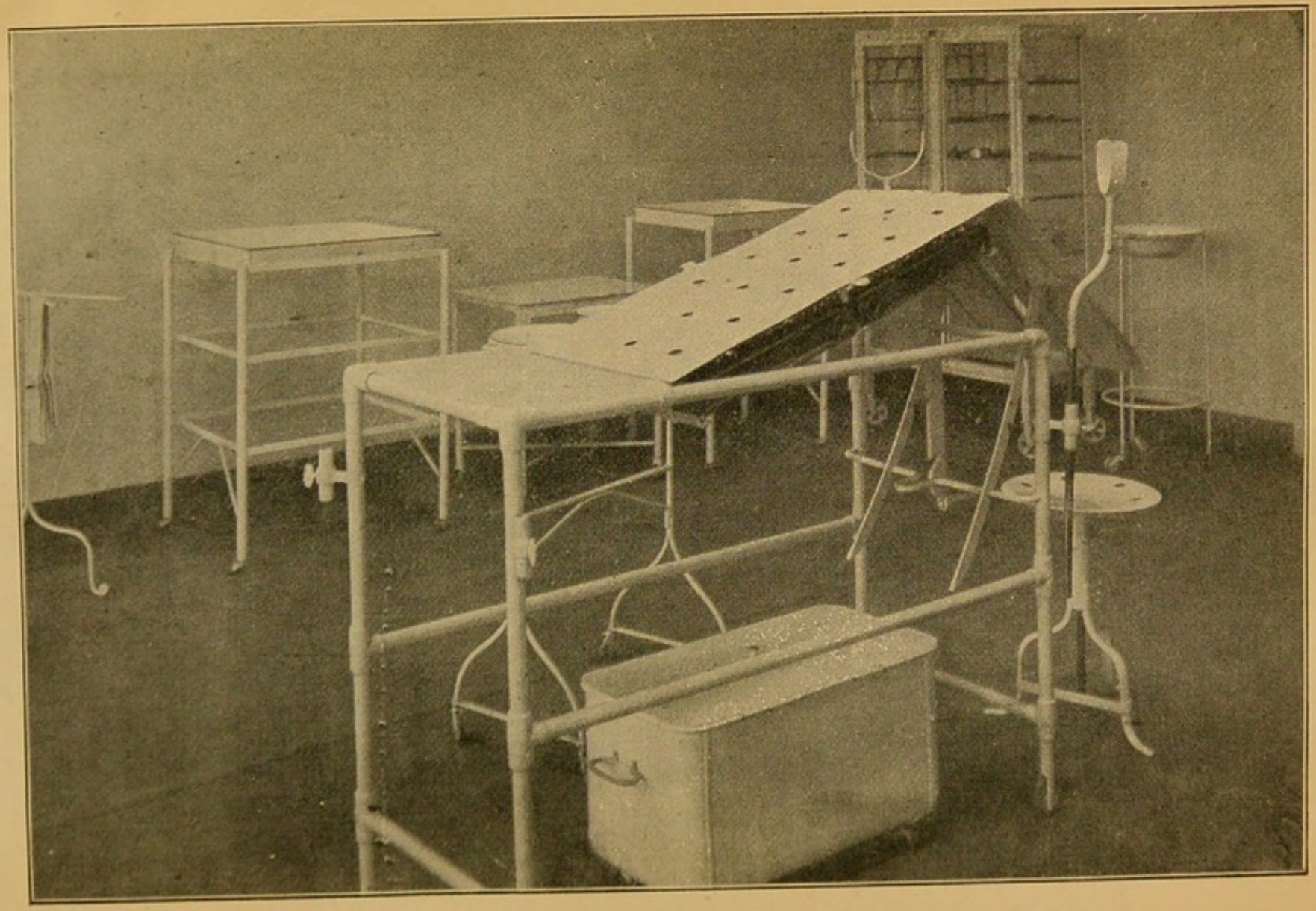

FIG. 4.

points (see Fig. No. 4). It is made entirely of white enamelled metal (iron), with head, body, and leg rests. It is 68 inches long and 36 inches high. The body plate is perforated, and to this is fixed a framework which holds two heating pans for hot water. About-two thirds of the top plate can be raised in a sloping position by a single lever to an angle of 40° to suit the Trendelenburg position, the heating pans rising even in this position with the top plate. It should be mentioned that these pans can be easily taken out, if required, during an operation to be emptied or filled. Only two of the legs of the table have castors, so that it is in this way prevented from sliding. When in the Trendelenburg position the table may be made into a gynæcological chair by using the sloped part as a back rest, and fixing the knee-rests at the head of the table instead of at the other end as seen in Fig. No. 4.

The *instrument cabinet* selected (see Fig. No. 4) has nothing special about it. As it was to stand in the operating theatre it was of as moderate dimensions as possible. It contains the usual adjustable shelves of plate glass, and has double plate glass doors and plate glass sides, so that everything in it is visible, and any instrument wanted can be at once seen. One part of it has been furnished with small brass rods and pegs so that forceps can be hung up by their handles. This is a convenient arrangement, and saves space. Being made of iron it is of considerable weight, but being on rollers it can easily be moved about. The utility of these large, unwieldy, and expensive cabinets for instruments is, to my mind, an open question. They have really sprung out of the ideal German aseptic surgery. What no doubt was aimed at was such a receptacle for instruments as would be quite dust-proof and would permit of the contents being taken straight out and used at an operation. I fancy there are very few surgeons that would be quite happy in their minds at using instruments under such conditions, and would not be content without their having a preliminary boiling or soaking in an antiseptic lotion. As this safeguard should always be followed, it is not necessary to provide a costly resting place for instruments between operations, and they are as well kept in the ordinary wooden cabinet of former days outside of the operating theatre, as then they are not exposed to the steam of the sterilisers in the theatre, which is apt to damp them, and has to be as much guarded against as dust.

Another article that required consideration as to selection was the large *steriliser* for towels, dressings, &c. It is quite possible to do without this, but it is useful in many ways in an hospital, and its use safeguards an operation in many points where error may creep in. The one chosen was the one devised by Lautenschläger of Berlin, and furnished with two copper cylinders, one inside the other. In the centre one are placed the dressings, contained in two round boxes (cartridge cases they are sometimes termed), with apertures in them which permit of hot steam permeating their contents. This steam may be generated in the instrument itself, as is usually the case, or it may be obtainable from some other source and may be forced in. In either case there is an arrangement for condensing the vapours escaping from the apparatus in a cooling vessel which stands beside it. I find from Miss Torrance, the matron of our hospital, that during the six months it has been in use this steriliser has worked very well.

Although water boiled for five minutes is quite sufficiently sterilised for surgical purposes, yet, as no special precautions have been taken to ensure that the water coming from the junction-taps has always been subjected to this heat, I considered it advisable to provide special apparatus for furnishing a liberal supply of sterilised hot and cold water for washing wounds and for other purposes during operations, so that I could be sure that only water previously sterilised by boiling would come into contact with the field of operation. This is done by the use of two *copper sterilisers* heated by gas, and holding several gallons of water (see Fig. No. 3). Two are necessary, as cold water is sometimes needed.

It is not possible to exclude *septic* cases from an operating theatre, but when they are within its walls every care should be taken that they do as little harm as possible. Hence, it is very necessary to have included in the furnishings a *box* with well-fitting lid for all soiled dressings to be at once placed in, so that no discharges may fall on the floor. The box selected is seen in Fig. No. 4, and is of a size to go underneath the operating table. It is on rollers, so as to allow of its being easily moved about, and, if necessary, removed from the theatre.

The only other article I would allude to is the *bottle and dressing stand*, seen in Fig. No. 3. It was made by Gardner & Son, of Edinburgh, and is very useful. On its shelves can be

placed various articles, and its top, protected by a rail, can be made available for the glass reservoir jars for lotions, thus doing away with the need of a shelf for them to stand on.

Such, briefly, is a sketch of the operating theatre at the Glasgow Cancer Hospital, and some months' experience of it has shown that it possesses all the necessary requirements. It has a warm, pure atmosphere, free from dust; it is pervaded by a good steady light; it is furnished with a plentiful supply of pure hot and cold water; and it is so constructed and equipped that it is quite in keeping with that one principle which, according to Schimmelbush should underlie the planning and arranging of every operating room from an aseptic point of view—viz., the provision of plenty of space and of every convenience for cleansing and disinfecting. All this has been obtained at a cost of under £250, which I regard as a reasonable sum, seeing that it includes price of floor, plastering and painting of walls, electric lighting, plumber work, heating apparatus, and surgical furniture.

Favourable, however, as the above conditions are for operating, they are not by themselves enough, and success can only, I believe, be absolutely and most easily assured by following the Listerian plan of procedure, which is really *aseptic surgery safeguarded by the use of antiseptics.* In hospital work, where students have to be considered, I regard it as the proper method to teach and practise. The supporters of aseptic surgery get, no doubt, excellent results, but they are more laboriously and expensively attained, and they are in no way better than those that follow from the use of a simpler procedure. Further, the aseptic system seems to me to have the drawback that it does not emphasise sufficiently the outcome of the general experience of surgeons—viz., that it is local contact that is the source of wound infection. If that is provided against, excellent surgery may be done amidst the simplest surroundings, for success in operations lies not in the marble floor and tiled walls of the operating theatre, nor in brilliancy of operating, but in care and attention to detail, and in applying to an operation wound the Scriptural injunction, "There shall enter into it nothing that defileth."