MILITARY ORTHOPAEDIC HOSPITALS.

BY

W. COLIN MACKENZIE, M.D.,

MEMBER OF THE COUNCIL OF THE ANATOMICAL SOCIETY OF GREAT
BRITAIN AND IRELAND, AND OF THE SURGICAL STAFF,
MILITARY ORTHOPAEDIC HOSPITAL, SHEPHERD'S
BUSH, LONDON.

PART I.—PRINCIPLES AND TREATMENT.

THE contributions made to surgical science by Great Britain in the last hundred or hundred and twenty years have placed the world for ever under a debt to the savants of this country. The discovery, about the year 1799, by Sir Humphry Davy that anaesthesia could be induced by vapour inhalation and the suggestion that nitrous oxide might be used with advantage during surgical operations;¹ the introduction of the antiseptic system by Lister, and the publication of the *Origin of Species* by Darwin which firmly established the principles of the law of evolution—these all effected a complete revolution on medical thought both as regards its theory and its practice. To show how great the revolution was a reference may be made to Lister's papers and more especially to the year 1873.² At that time a Scottish medical student was receiving his training in surgical wards from which hospital gangrene, blood poisoning and erysipelas had been banished, and he was witnessing operations under chloroform anaesthesia, the mortality from which in Syme's first series of 5,000 cases was *nil*. In anatomy not only could he, like Hunter, study man in relation to the animal world, but, thanks to the genius of Darwin, could study each animal in its sequence to some other. The law and order of function and structure took the place of chaos.

It is interesting to note that about that time a commission was sent to Edinburgh from Germany under Lindpainter. The wards of the hospitals of that country were foul with sepsis, and the magnificent hospital in Munich was about to be destroyed owing to the prevalence of blood poisoning, 80 per cent. of all wounds being affected by hospital gangrene. From this country, after a year spent in acquiring principles and methods, the German Commission took away a sound knowledge of the antiseptic system, anaesthesia, and of comparative biology—the three factors to which modern surgery owes its existence. After Lindpainter's return from Edinburgh not a single case of hospital gangrene occurred in the Munich Krankenhaus, and pyaemia and erysipelas were banished.

The effects on surgery of the introduction of the antiseptic—or, as called later, the aseptic—system were immediate. Its greatness was recognized throughout the world, and everywhere surgical wards and operating theatres were modelled on the British principle. The cranium, thorax, and abdomen could now be explored, and cases always regarded formerly as hopeless were rendered curable.

Unfortunately, the simplicity and power of the antiseptic system was not unassociated with danger. It placed a force in the hands of men who were apt to forget that a knowledge, if not of comparative, at least of human anatomy was the essential basis of all surgical treatment. If Lister regarded surgical treatment as largely a question of asepsis, it was because he recognized sepsis as surgery's curse, against which he bent his titanic energies, and over which he finally triumphed. Listerism was associated with action. In itself it did not convert the practice of surgery from an art into a science.

Why Britain's contribution to surgery stands unequalled is that not only did it introduce to the world the antiseptic or operative system but also its complement—the conservative system. Not only did it offer the world a system by which, for example, a tuberculous joint could be excised or explored without risk of sepsis, but also a method by which the joint, treated conservatively, could be absolutely cured. This complement we owe to a Welshman whose greatness is now only beginning to be generally recognized, and whose life, "teeming with good deeds done," was prematurely cut off at the early age of 57. I allude to Hugh Owen Thomas of Liverpool, of whom Professor Steele, the eminent American orthopaedic surgeon, in his oration on Thomas delivered before the Orthopaedic Congress at Washington,³ said: "In orthopaedic surgery more of originality and practical therapeutic suggestion has been given by no one. I have

greatly enjoyed perusing his works, and it has not been without profit; I trust that what he has left in print will be found in the library of every member of our Association, for from no single source within our own times has so much of orthopaedic originality and suggestive practice emanated."

As Thomas's work was so bound up with the principles of muscular action, and as we recognize that the restoration of muscular function to the normal is the foundation of all orthopaedic treatment, whether active or passive—and this applies equally to injury of muscle, nerve, nerve centre, joint or bone—a reference is necessary to certain fundamental principles connected with nerve and muscle discovered in this country, so that the position of Thomas can be clearly defined.

Professor Keith has told us that Hunter devoted a large amount of his time to the study of muscle and bone, and first distinguished between nerves of ordinary sensation and nerves of special sense. Hunter's Croonian Lectures⁴ on the physiology of muscular motion probably constitute his most important work. In studying movement not only did he go to the lowest forms of the Invertebrata, but also to the vegetable world, just as in investigating form he studied crystals. Hunter differentiated atrophy of muscle from disuse as well as from disease. He differentiated between velocity and force of action, and dealt with the adaptation of muscle to joint, and of muscles going over more joints than one.

He recognized that relaxation of muscle was a power as much depending on life as contraction, and not, as had been previously taught, a simple cessation of action. The state of rest he regarded as the state of inaction. "The elongation of a muscle is not the immediate result of its relaxation." Thus, if we take such an apparently simple movement as flexion of the finger, the stimulus which excites contraction of the flexors produces also a relaxation of the opponent extensors. The flexors by their contraction become the elongators of the relaxed extensors, and these relaxed and elongated extensors become by their subsequent contraction the cause of elongation of relaxed flexors. These two groups Hunter defined as "Reciprocal Elongators."

These reciprocal elongators, then, by their mutual action on each other bring out a middle state between the extremes of contraction and elongation, which is the state of ease or tone in both. Either extreme of motion leaves the muscle in an uneasy state. We find, then, that as soon as any set of muscles cease to act, the elongators, which were stretched during their action, are stimulated to act in order to bring these parts into a state furthest removed from the extremes which were uneasy and by which the stimulus arising from both is equally balanced. The elongated state of a muscle is an uneasy state—a muscle, therefore, that is stretched, although in a relaxed state, is uneasy, and will contract a certain length to what is probably the middle state.

We recognize that a muscle which has relaxed and elongated *pari passu* with the contraction of its opponent cannot at the same time be in a state of contraction. If the extensor communis digitorum extended the two distant phalanges we could not have extension of the metacarpophalangeal joint with flexion of the interphalangeal joints. Yet we can readily perform this. Nor could we have extension of the interphalangeal joints with flexion of the metacarpophalangeal, yet this normally also can be performed. A muscle cannot at one time help the extenders and at another the benders. To allow the opponent flexors to act, it, as an extender, becomes relaxed and elongated. Then, in some extraordinary way, this relaxed muscle fibre is supposed at the same time to be contracted and shortened to help the flexors.

Following shortly after Hunter came the brilliant researches of Charles Bell, whose classical work on the nervous system undoubtedly forms the basis of our knowledge of the physiology of the subject. For his work on respiration alone Bell's fame could stand. But Bell did more than that. In his own words he thus describes his great discovery.⁵

I have now only to add that my opinions and experiments have been followed up to the satisfaction of all Europe. It has now been acknowledged that the anterior roots of the spinal nerves bestow the

power of muscular motion, and the posterior roots sensibility. When the anterior roots of the nerves of the leg are cut in experiment, the animal loses all power over the leg, although the limb still continues sensible. But if, on the other hand, the posterior roots are cut, the power of motion continues although the sensibility is destroyed. When the posterior column of the spinal marrow is irritated the animal evinces sensibility to pain, but no apparent effect is produced when the anterior column is touched.

In the year 1832 Bell's experiments were followed by the discovery in London by Marshall Hall of the reflex function of the medulla oblongata and medulla spinalis. In addition to the three modes of muscular action previously recognized—namely, voluntary, that of respiration, and the involuntary—Marshall Hall recognized a fourth, namely, the reflex action.

The first three modes of muscular action are known only by actual movements or muscular contraction. But the reflex function exists as a continuous muscular action, as a power presiding over organs not actually in a state of motion, preserving in some, as glottis, an open and in others, as sphincters, a closed form, and in the limbs a due degree of equilibrium or balanced muscular action.

Not only did Marshall Hall discover and define "reflex action" but recognized the reflex function as the source of equilibrium in the muscular system. His original paper, read before the Royal Society,⁶ in which his experiments are detailed, should form part of the armamentarium of all orthopaedic students. Then will they recognize in true perspective the work of the minor satellites who have audaciously associated their names with side issues of this great discovery.

The basic principle of the study of anatomy during the time of the Hunters and the Bells was function. Largely through the influence of Cuvier in France and Owen in this country—although the latter was curator of the Hunterian Museum—the study of the functional system was superseded by that of the structural, and it is idle to deny that the descriptive method, with its pernicious examination backing, accounts for the negligence with which not merely comparative but human anatomy is studied. As Charles Bell himself wrote: "The one chief purpose in studying the anatomy of the human body is to understand its functions and to compare them with those of other creatures till we arrive at last at some distinct conception of the whole; of the various structures of animals and vegetables; and of the various functions which in each of these classes support life and action, and through it the principle of life."

With the publication of the *Origin of Species* and the placing of the Law of Evolution on an unassailable basis a new weapon for the study of function was placed in the hands of the medical profession. Function could now be studied from the point of view of correlation, and structure from the point of view of necessity. Yet even this mighty impetus has so far failed to slacken the hold of the descriptive system on the medical curriculum, although in the last few years there are all the evidences of change.⁷

Unfortunately the descriptive system received in the antiseptic system a powerful ally. Cleanliness, a knowledge of technique, and of position of the main bodily structures, have for the last half-century constituted the main armamentarium of the operating surgeon.

To concentrate our attention on function as embodied by conservatism was the ideal which H. O. Thomas formulated. For that ideal, unpopular then as now, he fought throughout his all too short life. It was a fight that required a man with giant energies and an unswerving belief in his own principles. With what contempt must the young surgeon have looked on Thomas, who, discarding the ease with which—thanks to anaesthesia and antiseptics—a joint could be excised, preferred to "cure" the joint by scientific rest. His death, just as in Hunter's case, excited little interest in his own country. Not so, however, in America and Australia, where the scientific value of his principles was well known. The mists of prejudice are now becoming cleared from men's eyes as it is realized more and more that Thomas's principles embody the application of the functional method to practice. This, after all, is the only scientific method, because it is founded on the basis of the true anatomy—namely, the biological or comparative.

Thomas made in all ten contributions to medical science, and of these the most important are *The Principles of the Treatment of Joint Disease*, and *The Principles of the Treatment of Fractures and Dislocations*. It is generally conceded that these principles are on the level of Hunter's Croonian Lectures.

Thomas can be regarded as the apostle of the conservative or rest treatment of joints, bones, and muscles—not surgical rest, so called, but anatomical rest. He knew, of course, that complete rest could only be attained *post mortem*. In his methods he aimed at effective immobilization, abolition of concussion, and avoidance of pressure.

To his medical knowledge he added a sound acquaintance with the principles of mechanics and mathematics. The keynote of his work is to be found in his knowledge of the physiology of muscular action. Thomas recognized that in inflammation of a joint the altered position relative to the normal which the parts comprising the joint assumed was due to muscular action and not to so-called increased tension. Increased tension he knew could not cause movement. He looked on muscles as sentries needing control but not structures to be forcibly stretched or subcutaneously divided, as was taught.

Hip and other joint deformities accompanied by inflammation arise mainly from the effort of the patient by the exercise of his will to pose the limb in the easiest position and fix the articulation, without which ease could not be gained. Knee-joints are not infrequently presented to the surgeon suffering from liquid distension only, which the muscles appear to know, for there is an absence of any deformity as there is no special muscular intervention. The articulation, however, is fixed more effectively by art than by the natural method of muscular action. In fact, a through fixation of a diseased joint is a physical method of physiologically suspending or disconnecting for a time muscle influence from a joint, and this inhibition of muscular interference will be the more complete just in proportion to the practical efficiency of mechanical aid.

Rest of the joint was secured by controlling all the muscles which produce or tend to produce movement. He rested the joint in the position naturally assumed in the inflamed condition owing to muscular action, the deformity being reduced gradually as the joint recovered. He gave relief to the unhealthy portion by action on the healthy—that is, he attached his controlling appliance to the sound portions only of the limb to which the diseased articulation belonged, and not as was usually advised to the diseased part, inasmuch as he knew that in this way the diseased area was subjected to pressure. Traction in the line of deformity he knew would be endless traction and that it was impossible for a flexed hip-joint to have its angle from the plane reduced if the traction were constantly at that angle.

No matter what the primary cause of the disease in a joint, whether it be induced by trauma, struma, syphilis, gonorrhoea, or rheumatism, rest cannot be dispensed with, for, if surgery does not step in, Nature is sure to intervene by the muscular method, knowing that arrest of motion is the one thing needful before all others. In man's evolution it was his only chance of recovery from hip-joint inflammation.

It was his practice when treating a diseased articulation by enforced rest never to test for motion so long as resolution of the disease was not seemingly established, and then in the gentlest manner possible. No amount of rest, he knew, would produce ankylosis in a joint free of disease. It might produce stiffness, which is only a trivial and temporary hindrance.

Between a stiff and an ankylosed joint is no analogy beyond the absence of motion. His views on ankylosis of joints are noteworthy, and were years ahead of his time.

In the condition of diseased articulation we find inflammation and the accident attendant on it—namely, deformity. To the treatment there can only be applicable the principle that the most perfect and continuous practical immobility should be enforced so long as unsoundness is known to exist. To this principle there is no exception. The more completely an unsound joint is maintained at rest, if the rest arrests friction and removes pressure, the sooner it will become sound and able to endure pressure and

friction, the probability of ankylosis remaining is diminished, but if ankylosis results—and it cannot always be avoided—it should be accepted not as evidence of defective treatment, but rather as an indication of the intensity of the disease. The purpose of treatment should not be to induce ankylosis, as is so often done under the supposition that such a limb is better suited to the wear and tear of use, or that relapse and recurrence were not so liable to happen if ankylosis of an articulation occurred. An unsound ankylosis is quite as liable to retrogression with motion as an unsound joint. Deformity is evidence of Nature's attempts to secure rest for the articulation by fixation of the joint. It is Nature's mode of immediate help. Ankylosis is Nature's reserve assistance. Ankylosis prepares to fix the joint when the method by muscular control begins to fail. The surgeons of the past judged deformity to be an unavoidable defect, and ankylosis as often a necessary evil. But deformities are avoidable, and ankylosis is in no instance to be desired, though it may be in the presence of certain conditions an unavoidable termination. The fact that there has hitherto been no sure test of recovery has led to the belief that joints which have been excised are less prone to subsequent trouble from recurrence of unsoundness. It has always been a favourite argument that without excision the diseased joint is the subject of frequent and unexpected relapses, whereas the real cause of relapse has been the fact that treatment was in past time suspended ere soundness of the articulation had been secured.

Thomas was careful to distinguish clinically between healthy, inflamed, ankylosed inflamed or unsound, ankylosed but sound, sound or recovered, and deformed joints.

In an unsound ankylosis progressive and evident motion will follow use if the limb in which the ankylosis exists be employed for its usual purpose, while in an ankylosed but sound articulation ordinary daily use cannot bring on any variation of position, an indication that such condition should be termed true ankylosis. An inflamed joint is an articulation the radius of action of which is gradually diminishing. The diminished radius of action designated joint deformity tends to increase so long as the joint is unsound and untreated, and is caused solely by the efforts of Nature to practise immobility as a means towards aiding restoration. A sound or recovered joint is one from which traces of previous inflammation have passed away. In evidence of this sound condition and complete recovery it is noticed that by ordinary daily use the radius of action to and from the position maintained during treatment is seen to be gradually increasing no matter in what position the limb may have been fixed during treatment—an infallible sign of soundness and a justification for no further restraint or surgical interference.

He protested against the terms true or bony and false or fibrous ankylosis.

The expression false and true ankylosis should refer to the permanency of the rigidity, not to its structure; that is, no ankylosis which will vary either by test or use should be termed true ankylosis and no ankylosis which remains immovable by either test or use should be termed false ankylosis. As long as false or unsound ankylosis lasts there is always a prospective chance of recovery with complete or some motion by use alone.

He was careful to insist on a utilitarian position should ankylosis be inevitable. At the elbow flexion not extension; at the hip and knee extension; at the ankle with the foot at a right angle; at the wrist dorsiflexion, ordinary flexion giving a weak finger grip in grasping. In vehement terms he denounced the breaking down of contracted joints, a practice which unfortunately is still followed by the ignorant.

Joints that have perfectly recovered either from injury or disease regain motion earliest by their being employed in their ordinary manner. Joints that are not in a healthy condition automatically resent attempts at compulsory employment. Passive motion applied to joints injured or diseased delays recovery, and if applied to joints cured it delays the event of complete restoration of function. The good repute which the public has given to bonesetters, osteopaths, passive motionists, shampooers, manipulators, and Bethshanites rests upon the fact that these unscientific practitioners get the charge of joints and

fractures when their cure has been consummated and merely preside during the resumption of function. They only watch the rising sun and profess to assist its cure practising certain flexions, extensions, twists, jerks, and pushes, with passive motions and other details evidently intended to give proper dignity and importance to their proceedings. The treatment, however, which the sufferer is most in need of he seldom meets with—namely, no motion. As soon as the part under treatment has become healthy it will resume its function more fully and readily rather by the attempts of the late patient to use the part than by supplemental violence, such as passive motion or violent manipulations. If the part be sound its range of function increases with use. If ankylosis can possibly wear off it does so best by the patient's attempts at ordinary use of the part.

Treated on the above principles, he confidently asserted that every case of hip-joint could be cured without leaving a fractional deformity of flexion, and consequently without any shortening except that arising either from the arrest of growth where inflammation has interfered with the growing points in the upper part of the femur or from erosion. He asserted the same as regards the treatment of knee-joint disease. He was a bitter opponent of the indiscriminate excision of joints.

Joints injured or diseased when they show no signs that may lead us to think they can recover, should be amputated. My contention has been that the joint that can recover after excision can recover without it, and joints that do not recover after excision ought to have been removed by amputation.

He never once excised an elbow-joint, and states:

I have never met with a case of excision of the elbow which equalled in usefulness a diseased elbow-joint truly cured. Even if ankylosis remain, the part, if sound, is less liable to relapse or give future annoyance to the patient than after an excision, however successful.

That has been the experience of Peter Bennie, the distinguished Australian surgeon, during thirty years' application of Thomas's principles. "I have never," he writes,

"seen a case in which amputation for hip disease was necessary, and if the joint is properly fixed by a Thomas hip splint excision will never be required."

To put these principles into practice Thomas introduced to the profession many ingenious

appliances, of which the best known are the hip or dorsal fixation splint and the knee splint, the varieties of which are the "bed" for resting and the "caliper" for walking, which latter, by transmitting the weight from the hip to the heel, enables the patient to walk with the knee at rest. The knee splint has been the most universally used splint in the war. The hipsplint, though quite simple in construction, is probably the least understood of all his splints;

this, however, is the result of prejudice and of ignorance of principles both of mechanics and of rest. It is the only splint in the world whose application has been raised to a science. I allude to P. B. Bennie's formulae

FIG. 1.

FIG. 2.

FIG. 1.—The double Thomas hip splint applied. (After Thomas.)

FIG. 2.—The caliper knee walking splint. (After Thomas.) E, Ring at upper thigh. B, Band behind knee. A, Band behind lower third of leg. F, Inserted into socket in boot heel.

for the accurate fitting of the splint and the correction of deformities. One formula is:

$$\sin \theta = \frac{\cos \alpha, \sin \beta}{\sqrt{(1 - \cos^2 \alpha, \cos^2 \beta)}}$$

Where θ = angle through which the plane of the splint is rotated in the direction of the lateral displacement, α is the angle of flexion required calculated from 0° as normal, and β the angle of adduction or abduction, the rotation being made just above the joint and the flexion opposite the joint.⁸

For elbow flexion Thomas used a halter and collar; for the wrist a simple tin splint to hold the joint in the position of dorsiflexion; for the dorso-lumbar spine a cuirass; for cervical disease a leather collar; and for ankle disease the simple "crab" splint.

Thomas's work on fractures is pregnant with original ideas. A brief mention may be made to some important

FIG. 4.—The combined hip and ankle splint illustrating a simple means of resting hip, knee, and ankle joints.

principles. Efficient fixation, he asserted, best assists the restoration and repair of the part fractured.

Perfect rest of a fracture, if it could be maintained without supplemental art and interference would best permit the repair of fractures up to a normal condition. If a fracture is in proximity to a joint the limb ought to be so fixed that the utmost prospective usefulness may be afterwards gained should the joint have also suffered an injury indirectly.

In fractured olecranon he merely advised the extended position, but if the fracture were compound, flexion, he said, should be maintained during treatment lest the injury may run a course ending in the loss of motion of the joint.

He was careful to distinguish between non-union after fracture of bone and delayed repair.

Non-union should apply only to those fractures which have resulted in a cartilaginous, or otherwise, connexion having formed between the points of fracture—the bony points not being in actual contact. Examples of delayed repair are common, while those of non-union are rarely met with. The gravity of delayed repair depends on the locality. If found in the shaft of a bone it is not so easily remedied as when it occurs at an extremity.

FIG. 3.—Effective rest of right hip-joint by Thomas's dorsal fixation splint. (After Bennie.)

He states that in the early years of his practice he invariably interfered with instances of delayed repair by saw, wire, rasping, and pegging, but during the later years he succeeded better without direct interference, although most of his cases were less hopeful of success than his earlier cases.

In these days of antisepsis it is not uncommon for even a recent fracture, especially if compound, to be at once drilled and wired or pegged, when ordinary mechanical appliances intelligently used would be better. This practice I hold to be a retrogression in the surgery of fractured bones; indeed, if we are more thoughtful of the fact that it is living matter that we have to manage, then it would seem that even in delayed union of fractures actual interference, such as drilling and excising, will seldom

be required—nay, it will be found that such operations are in some instances a hindrance rather than an aid to repair, and operations of this character would then be reserved for old chronic cartilaginous connexions only.

He preferred to give cases of delayed union conservative treatment before operating—stimulating the part by compression and percussion combined with efficient fixation of the fractured area. At first he did not regard efficient fixation as essential, but later insisted on it as he found the time for repair shortened. By this mode of treatment he was invariably successful. Percussion was applied with

FIG. 5.

FIG. 5A.

FIG. 5.—The simple "Crab" splint for resting the ankle and foot.
FIG. 5A.—The same applied. (After Thomas.)

FIG. 6.—Gunshot wound of upper end of left humerus rested on upper limb abduction splint.

a rubber-protected mallet all round the site of fracture—the skin being protected by felt—about every third day for four weeks. Prolonged tumefaction for a distance around, above and below the fracture, was enforced by means of rubber bands. In a case of ununited fracture of

the humerus of nine months' standing, which he treated successfully, he practised percussion weekly for four weeks and practised daily for half an hour "damming" the circulation around the fracture. It is interesting to note that he regarded percussion as a means of bringing about an increase of bony structure even in cases of non-fracture. It is important to remember that Thomas was the originator of the congestive or hyperaemic treatment, although it received little notice in this country till associated with the name of a foreign surgeon.

Muscle.

Thomas's important contribution to the surgery of nerve and muscle is that associated with the treatment of dropped wrist. More important than that, however, is his explanation of so-called contracted muscle and contracted tendon:

The term contracted muscle is a misnomer—a shortening of true muscular tissue from long-continuous action does not occur. Neither true muscular nor true tendon structure, as long as it is not diseased, can be shortened or lengthened. During the action of true muscular structures the fibrous ramifications radiating from the tendinous origins

and insertions of muscles and connecting the true muscular structure become wrinkled, and if the true muscular tissue remain long and continuously active the folds of fibrous tissue become obliterated; and when the true muscle is tired out the contraction of this tissue acts to mechanically fix in a special position the part subjected to the control of that muscle.

This, together with alterations in the form of and around the articular capsule and possible connexions between the bones forming the joint he regarded as the factors maintaining the permanency of joint deformity. As a clinician he noticed that muscles possessed of much divergent

fibrous tissue, as soleus and gastrocnemius, are the most prone to permanent and obstinate contraction, while much permanent rigidity of muscle is seldom met with

in such a muscle as the sartorius, which possesses little fibrous tissue, except at origin and insertion. As further evidence, he regarded the fact that the true muscle of a tendon that has been severed will resume duty in a few days. An unhealthy condition of a joint and the necessity to place the components in the position of ease, constituting deformity, become the stimulus to contraction of one set of muscles and to relaxation and elongation of the opponents. In a joint deformity we are always dealing with these two factors. This muscle state is maintained as long as the necessity persists, but the muscles themselves are not diseased. If the abnormal position be prolonged owing, for example, to the severity of disease, reduction may be interfered with by secondary changes—namely, contraction of the intermuscular fibrous tissue, alterations in the capsule or perhaps bony or fibrous connexions between the joint surfaces.

Recognizing these factors and also that the deformity has been gradual in development—the contracting and shortening of one muscular group occurring *pari passu* with relaxation and lengthening of the opponents—such a procedure as forcibly breaking down a contracted joint must be condemned as absolutely unscientific and only worthy of charlatans.

Wrist-drop.

In the condition known as "wrist-drop," Thomas, instead of assuming that this was permanent and irremediable, argued that the primary cause may have been temporary, and that elongated extensors were mechanically prevented from contracting. They were not of necessity permanently paralysed and stretched. For purposes of prognosis he used a simple and effective test. "If the

FIG. 7.

FIG. 7A.

FIG. 7.—The Robert Jones abduction frame. Used especially for old ankylosis of hip and to overcome shortening in malunion of femur. FIG. 7A.—The same applied.

FIG. 8.—Long plaster "cock-up" splint for musculo-spiral paralysis.

vented from contracting. They were not of necessity permanently paralysed and stretched. For purposes of prognosis he used a simple and effective test. "If the

patient be asked to try and perform by the exercise of the will only greater flexion than already exists, the fingers flex readily, and also by the act of the will extend forward again to the position of previous repose." Furthermore, "while the wrist is firmly flexed by supplemental assistance the patient can by the exercise of his will within a small radius rapidly flex and extend his fingers." Success in these tests enable a favourable prognosis to be given, and Thomas was successful in a case of eighteen years' standing. A recent case usually recovers in one to four weeks and an old one in six to twenty weeks. In treatment by means of a simple "cock up" splint the hands and fingers are maintained in relation to the forearm in the position of extreme extension "so as to allow the muscular tissue of the extensors of the wrist and fingers to retract from the overstrain or overdraw." On removal of the splint by the surgeon to test the result, "should the patient by the exercise of his will be able to maintain extension, the surgeon may allow the limb to be used, discontinuing the angular extension apparatus." Thomas did not of course regard this treatment as universally successful in all cases of dropped wrist or ankle, and in connexion with poliomyelitis he wrote:

It is my experience that those cases which we meet with after infantile paralysis of the upper extremity are the most untractable because that the central nerve lesion in these cases is never perfectly recovered from; and, again, in many of these cases we have to contend with a dropped condition of shoulder, elbow, wrist, and fingers in subjects who do all they possibly can to thwart our endeavours to assist them.

Thanks to Robert Jones, these important views of Thomas on muscle, greatly amplified, have been introduced to the notice of the profession, and it would be idle to deny that round them is being built up the modern surgery of nerve and muscle injury.

Nerve Lesions.

Thomas directed our attention to the treatment of muscle in cases of nerve injury. Weakened or paralysed muscles must be rested just as a diseased joint or bone must be rested. The healthy opponents should not be allowed to contract, producing a stretching of the weakened group. Such conditions as contracted fingers or joints should never be allowed to occur, and should they be present they should be remedied before any operation is undertaken. In recent cases of divided nerve, where the diagnosis is certain, a reparative operation is essential. In old cases it is surprising what improvement can be effected by means of rest, together with scientific re-education aided by the patient's volition. Speaking generally, no operation should be undertaken till these methods have been exhausted.

In cases of injuries of nerves the ends are freshened and sutured. If a gap exist between the divided ends it may be necessary to flex a joint—for instance, as the elbow—or alter the position of the nerve. Should these fail, the gap may be bridged by a long segment of a sensory nerve or by strands of catgut, but it must be remembered that such operative treatment is only the beginning. The mere transmission of an impulse along a sutured nerve is not sufficient to cause recovery of muscular action, and that is the important thing. The muscle must be rested and re-educated from zero. Its recovery must be along biological lines—that is, along the lines of the acquisition of its mammalian function.

Stimulated by the work of the Liverpool School of Orthopaedics, much research work has been carried out on the evolution of muscular function throughout the mammalia so as to form a scientific basis for muscle re-education. Furthermore, in cases of muscle transplantation to strengthen the weak, or muscle lengthening or division to weaken the strong, it is important to remember that certain muscles in the economy are "survival results," and that by the comparative method we are enabled to estimate the relative value for grafting—for example, of the two peronei or the two tibials, or the brachio-radialis.

In connexion with military orthopaedics it should be remembered that Thomas first introduced three simple methods of treatment which are now universally recognized.

He taught us that spinal curvature was frequently associated with inequality of length of limb, and that

an essential in treatment was to raise the boot on the shortened side.

Inflammation of the metatarso-phalangeal joint of the toes, especially the great toe, to which soldiers are liable, can be relieved by a piece of hoop iron or leather "so placed under the shoe sole that its front margin is just under the joint, so that in marching the toes miss concussion with the ground as the patient advances the opposite foot."

The Thomas boot for flat-foot, with the oblique heel and the raised sole and heel on the inside, is well known. By its means strain is thrown off the inside of the foot, the tibial muscles are given a chance to strengthen, and the tendency to displacement of the internal cartilage of the knee to which these subjects are liable is obviated.

I have dealt at some length on the principles of Thomas because, although principles of rest were enunciated by Brodie and Hilton, he was the first not only to enunciate doctrines of conservatism but also to offer simple mechanical means by which these could be put into practice, although at his death his work was largely overshadowed by the operative system owing to the introduction of antiseptics. Thomas fortunately was succeeded in his practice by Robert Jones, who had the rare privilege of having worked with the master himself during the later years of his life. Thanks to him Thomas's work has been widened in its application, numerous improvements have been introduced, and scientific workers have been attracted to Liverpool from all parts of the world to learn those conservative principles which, like Thomas, he has always taught as forming the foundation of surgical practice. Thus in appointing Colonel Robert Jones, C.B., as Inspector-General of Military Orthopaedics, the War Office placed the treatment of the deformed soldier under the control of one who, himself trained in the modern aseptic school, is recognized as the greatest living exponent of the conservative method. In him the complementary schools of British surgery have been effectively combined. The British soldier who has suffered division of a nerve is assured not merely of a successful aseptic operation of suture, but of prolonged conservative treatment directed to the scientific stimulation and re-education of the affected muscles. Should these methods be unsuccessful, recourse may be had to the operation of muscle grafting, by means of which a flexor is asked to act as an extender and an extender as a bender as the result of alteration of muscle insertion.

A fractured bone, even if union be delayed, may be treated by various methods of conservatism, but should these fail resort may be had to the operative methods of pegging, bone grafting, and plating, for the advance in which department of surgery the profession is under a debt of gratitude to the genius of Sir Arbuthnot Lane. Should the femur be shortened it may be re-fractured and lengthened by the assistance of the abduction frame of Robert Jones. Joints, should they be deformed, are not forcibly torn down or excised, but gradually reduced, so that recovery in one set of muscles is always correlated to that of the opponents. By anatomical rest of joints and bones amputations of limbs are obviated; the soldier with a displaced fibro-cartilage of the knee, the replacement of which is always easy and usually spontaneous, is rested so as to allow rupture of the collateral tibial ligament on which it largely depends to repair, and when the patient resumes walking his boot is built up on the inside to prevent recurrence by relieving strain on the inside of the knee. Only in cases of recurring displacements due to an unrepaired collateral ligament is resort had to removal, which, as described by Robert Jones, is almost a minor operation. By means of the Thomas boot and simple manipulative measures the soldier with even a severe flat-foot can be treated successfully without operative interference which is reserved for extreme cases.

What a difference in the lot of the British soldier, treated in 1815, after Waterloo, by Sir Charles Bell, admittedly the greatest anatomist and surgeon of his time, compared with the treatment of 100 years later! It is hard for us to realize that Bell in his paper was dealing with scenes of only a century ago. In this short period of time, thanks largely to the genius of our countrymen—although we render homage to the names of Lavoisier, Lamarck, Cuvier, and Pasteur—the antiseptic system, anaesthesia, the conception of vaccine treatment, the placing of the physiology of

nerve and muscle on a sound basis, the publication of the *Origin of Species*, and the establishment of conservative surgical principles, have all been introduced. Without these no modern orthopaedic work would be possible. To these we must add *x* rays; and although we pay respect to Roentgen for his great discovery, we must always remember that the Crookes's tube was discovered in this country. We can recall with no little pride that these great discoveries have been freely given to the world for the benefit of humanity.

PART II.—STATEMENT AS TO MILITARY ORTHOPAEDIC HOSPITALS IN GREAT BRITAIN AND THEIR EQUIPMENT.

Orthopaedic cases comprise in one form or another a large proportion of the men invalided from abroad with severe surgical injuries.

Military orthopaedic cases are held by the Army Council to include the following:

- (a) Derangements and disabilities of joints, simple and grave, including ankylosis.
- (b) Deformities and disabilities of feet, such as hallux rigidus, hallux valgus, hammer toes, metatarsalgia, painful heels, flat and claw feet.
- (c) Malunited and ununited fractures.
- (d) Injuries to ligaments, muscles, and tendons.
- (e) Cases requiring tendon transplantation or other treatment for irreparable destruction of nerves.
- (f) Nerve injuries complicated by fractures or stiffness of joint.
- (g) Certain complicated gunshot injuries to joints.
- (h) Cases requiring surgical appliances.

These cases naturally fall into two groups—those whose disablement is only temporary and who after treatment will be fit for military service again, and those who are so disabled that they must inevitably be discharged from the army.

The wounded soldier receives immediate treatment in a general military hospital. If his case comes into the category of orthopaedics, as defined above, he is then transferred to one of the orthopaedic centres for special treatment.

If his disablement has been only temporary, he may be sent for after-treatment to a command dépôt until ultimate recovery and return to military duty.

Command Dépôt.

A command dépôt is officially defined as a convalescent camp equipped with facilities for electrical and massage treatment under medical direction, but mainly organized and controlled under purely military officers, with the object of hardening men by suitable exercises and graduated drill for return to active service at the front in a period of about six months.

The men live in huts. Beds are wooden forms with straw palliasses and military blankets. Ordinary diets only are given. The huts are heated by stoves.

The cases suitable for admission to a command dépôt are:

1. Men recovering from gunshot wounds not involving joints or nerves.
2. United nerves giving normal action to muscles.
3. Pott's fracture, Colles's fracture, with no ankylosis of joints.
4. Injuries to left hand not to such a degree as to prevent the use of a rifle.
5. Simple myalgia without obvious organic symptoms.

All scars should be firmly healed and not situated at points of regular pressure of equipment, for example, shoulder, scapula, waist.

Spinal injuries when there are resultant symptoms as headache or paresis; shell shock with the slightest tremor or mental impairment; paralysed limbs, drop foot or hand, and neuritis, are not considered suitable cases for admission.

The command dépôts are visited regularly by an orthopaedic surgeon, to help the staff in their choice of cases for orthopaedic treatment.

List of Command Dépôts in the United Kingdom.

Name of Command Dépôt.	Accommodation for Men under Treatment in Addition to Permanent Staff.	How Allotted.
Shoreham	5,000	Eastern Command.
Seaford	5,000	London District R.E.
Sutton Coldfield ...	2,000	Southern Command.
Ballyvonare	4,000	Southern Command.
Tipperary	4,000	Irish Command and Eastern Command.
Randalstown	3,500	Scottish Command.
Ripon North	6,500	Northern Command R.A. (Regular and I.F.); Machine Gun Corps.
Alnwick	3,400	Northern Command.
Knowsley Park	4,000	Western Command.
Heaton Park	4,700	Western Command.
Eastbourne	2,000	Cavalry whose Reserve Regiments are in the Eastern, Southern, and Aldershot Commands; Yeomanry whose 3rd Line Units are in the Eastern Command, Army Cyclist Corps; South African Contingent.
Blandford	600	63rd (Royal Naval Divisions) (only).
Amphill	877	For Infantry (Regular and I.F.) whose dépôts are situated in No. 9 District, preference to Bedfordshire soldiers.
Total beds	45,577	

The soldier who is permanently disabled and utterly unfit for further military service undergoes similar treatment in the general and orthopaedic hospitals, and is finally discharged and pensioned.

Curative Industries.

In each orthopaedic centre, besides surgical operations, massage, electrical treatment, hydrotherapy, and gymnastic exercises, a series of curative workshops have been established with successful and valuable results.

These curative industries serve a twofold purpose. First of all—and this is most important—they are directly curative by giving exercise, under the surgeon's control and supervision, to the affected part. They are also indirectly curative through their profound psychological influence upon the patient. Apathy and inertia are replaced by bodily and mental activity. In the second place, these industries enable a certain number of the men to acquire a craft or trade, by which they will become more valuable to the community by the increase of their wage-earning capacity after discharge.

A minor point that experience has shown very clearly is the monetary value to the institution of the work done, such as splint making, carpentering, painting, etc.

The curative workshops are an important evolution in the war. In each orthopaedic centre they form an essential part of the treatment, with local differences dependent on the character and staple trade of the district. For example, in Aberdeen a net-making industry has proved highly successful, and in Bristol basket making.

The permanently disabled soldier is not lost sight of after discharge from the hospital and the army. He then comes under the care of the Statutory (Pensions) Committee. He may be quite fitted for civilian employment, in which case he may at once resume his old trade or seek new employment. He may find a place in one of Lord Roberts's memorial workshops; or he may elect to undergo further training for a new craft or trade. The advantage of the establishment of curative industries in the orthopaedic centres becomes obvious. The technical schools of the country have placed their resources at the disposal of the Statutory Committee, and it is understood that arrangements are being made for the intensive education of suitable pensioners at these institutions.

When a man is transferred from a general hospital to a command dépôt it means that his disability is temporary, that he belongs to Group 1, and that he is considered likely to be fit for active service within six months. If, on

the other hand, he is transferred from a central hospital to an orthopaedic hospital he may belong either to Group 1 or Group 2. If to the former, his disability must be necessarily more severe than that of the man sent to a command dépôt, and the treatment required to fit him again for active service may of necessity be prolonged. If, however, he belongs to the latter, Group 2—if, that is, the medical authorities of the central hospital decide that his disability is such as to prevent him from ever becoming fit for any form of military service owing to the fact that he suffers from such a lesion as, for example, severance of the right sciatic nerve with foot-drop, he may also be sent to an orthopaedic hospital. If there were always available beds at orthopaedic hospitals these patients could be automatically transferred there from the central hospitals without delay, but the length of time involved in the treatment of patients at orthopaedic hospitals of necessity greatly lessens the number of new patients that can be admitted in any one year. The length of stay of the individual is prolonged, and at present this is a very real difficulty; because of this lack of accommodation at orthopaedic hospitals men may have to be brought before invaliding boards and discharged from the service at central hospitals who still require to begin skilled orthopaedic treatment. The fact, however, that a man has been discharged from the army does not prevent him from attending an orthopaedic centre as an out-patient or from subsequently being admitted for further treatment to an orthopaedic hospital, but it is a break in the logical sequence of treatment. Among this class of case may be patients with injuries of the musculo-spiral, median, and ulnar nerves, and hemiplegias after head injuries.

This difficulty is being met by the establishment of more orthopaedic centres and special annexes, but the numbers of beds will have to be very large, for these cases are a numerous and growing class. At present the War Office allows any discharged soldier disabled by the war to obtain further treatment at a military hospital, if he requires it, and these men can always seek out-patient treatment at a military orthopaedic centre or hospital; but here again we are faced with the difficulty that they may not live within several miles' walking distance and cannot, therefore, obtain treatment. Recognizing our debt to these men and their future value to the State, it is essential that skilled orthopaedic treatment, based on a scientific knowledge of the principles of surgical rest and of the anatomical and biological methods by which recovery of muscular function can be obtained, together with the mechanical training necessarily accompanying these, should be made available for them. Disabled soldiers fall obviously into two classes: (1) Those who are wholly permanently disabled for any kind of work; (2) those who may by re-education be restored to social and professional efficiency in varying degrees. The recognition of what patients constitute class (1) can only be left to skilled orthopaedic surgeons and be based on the principles above enunciated. How to best treat those comprising class (2) is the present urgent question, but enough has been said to show that the problem, at least from its medical side, is being energetically and adequately grappled with.

I must especially thank Major C. V. Mackay, M.D., R.A.M.C., of the King George Military Hospital, for

numerous valuable suggestions and for his assistance in drawing up the plan on which this information is based.

Orthopaedic Centres in the British Isles.

There are now fully established ten orthopaedic centres in Great Britain and Ireland.

In England there are already four, of which one is at Shepherd's Bush. The other orthopaedic centres in England are: Alder Hey, Liverpool, the first to be formed, under Colonel Robert Jones; Leeds, and Bristol. It is proposed to found additional centres at an early date. In Wales the orthopaedic centre is at Cardiff.

Two centres have been established in Ireland, one at Belfast, one at Blackrock, Dublin. In Scotland there are three: Bangour near Edinburgh, Aberdeen, and Bellahouston, Glasgow.

The same general scheme of treatment is adopted in each centre under the supervision of Colonel Robert Jones.

It may be mentioned that each orthopaedic centre deals, in addition to the repair of deformities, with the preparation of the stumps of limbless soldiers before admission to Roehampton and other hospitals where artificial limbs are provided.

List of Orthopaedic Hospitals and Centres in the United Kingdom.

Military Orthopaedic Hospital, Shepherd's Bush, W. 1,000 beds.

National Orthopaedic Hospital, Great Portland Street, W.C. 170 beds.

Military Orthopaedic Hospital, Alder Hey, Liverpool. 850 beds.

Welsh Metropolitan War Hospital, Whitechurch, Cardiff. 500 beds.

Beaufort War Hospital, Fishponds, Bristol. 500 beds.

2nd Northern General Hospital, Beckett's Park, Leeds. 250 beds.

Bellahouston Hospital, Glasgow. 400 beds.

Bangour Hospital, Edinburgh. 400 beds.

Oldmill Hospital, Aberdeen. 250 beds.

Belfast U.V.F. Hospital. 300 beds.

Dublin. 200 beds.

The Military Orthopaedic Hospital, Shepherd's Bush, London, may be described as typical of all the centres. It is fully equipped, and has a visiting and resident medical staff. It is under the personal supervision of the Inspector, who visits weekly. The number of patients admitted from the opening of the hospital on March 1st, 1916, to February 28th, 1917, was 2,870, and the number discharged 2,101.

The following list of the discharged patients is important as showing the beneficial results of treatment:

	1. Duty.	2. Command Dépôt.	3. Re-classifi- cation.
1916.			
March	2	5	—
April	14	14	4
May	14	16	8
June	9	27	11
July	36	17	12
August	24	29	21
September	20	41	14
October	46	55	26
November	27	62	25
December	19	57	18
1917.			
January	34	27	16
February	17	32	26
	262	382	181

FIG. 9.—Patients returning from France suffering from gunshot wounds of the knee rested in Thomas's "bed" knee splint.

The majority of the patients under Class 3 (re-classification) were able to undertake mild forms of military duty, thus relieving fitter men for active service.

In reference to discharged patients it is important to bear in mind that owing to more rigid army regulations the discharge of men from the army to civil life as "unfit for further military service" has recently been considerably curtailed.

Apart from the question of available beds, there is no difficulty about the admission of a discharged soldier into this hospital for further treatment. On March 1st, 1917, the number of discharged soldiers in the hospital was 50, and there were 10 out-patients.

Electro-therapeutical Department.

This department is under the supervision of Captain Rowley Bristow, R.A.M.C., F.R.C.S. During the period July, 1916, to March 1st, 1917, the number of treatments given in the department was 19,000, and the number of new patients dealt with 728.

Type of Case.—The cases dealt with were mainly:

1. Peripheral nerve injuries.
2. Stiff joints with muscular wasting.
3. Atrophy of muscle.
4. Adherent and painful scars.
5. Functional conditions.
6. Trench feet and allied conditions.

Staff.—The staff consists of fourteen trained masseuses A.P.M.C. working under the direction of a surgeon in charge.

The electrical treatment of muscle is largely carried out by a specially wound faradic coil introduced by Captain Bristow. This coil is arranged so as to yield a current which is as nearly as possible painless, and which is under the control of the operator, so that the intensity of the stimulus can be altered from moment to moment. Rhythmical graduated contractions of muscle are brought about by this method. The muscle to be treated is made to contract gradually from zero to the desired maximum, and then allowed to relax. It is allowed to remain fully relaxed for a second, and then again stimulated. The left hand of the operator grasps the muscle and appreciates the degree of contraction, whilst the right controls the intensity of the stimulus. In this way the exact degree of contraction desirable for each muscle or muscle group is obtained. The control by hand is essential for the most efficient method of working, and no motor-driven or other form of mechanical interrupter can replace this control efficiently. With trained operators there is no risk of muscles being stimulated to the extent of causing fatigue, and so retarding progress. The main differences between this coil and the ordinary faradic coil are:

The special coil has thick wire in both the primary and secondary windings, and the number of layers in the secondary is less than in the primary—5:3. The interrupter can be exactly regulated by a sliding weight. A condenser of appropriate capacity is placed in circuit, to damp out the spark and assist in reducing the "skin effect" to a minimum.

The intensity of the stimulus is varied at will by (1) using either one, two, or three layers of the secondary; (2) by pushing in or withdrawing the soft iron core in the primary.

Massage.

The massage department is under the supervision of Dr. J. Mennell, and is equipped with all modern appliances for mechanical treatment. There are twenty-three trained assistants in the department—namely, twenty-one masseuses and two masseurs.

The number of patients treated and discharged from March, 1916, to March, 1917, was 863. On March 1st, 1917, the number of patients under treatment was 280. The average number of weekly treatments is 1,680.

Gymnasium and Hydrotherapy Department.

A large gymnasium is now in course of construction, to which patients will automatically pass from the massage department. The plans for a hydrotherapy department have been completed, and a building will shortly be placed under construction. Both these departments will be under medical control and in the immediate charge of trained instructors.

The Curative Workshops.

The curative workshops are of utmost importance. In these workshops the men are given a definite, regular, and interesting occupation, and energy instead of being wasted is directed to serve some useful purpose. These workshops, which are under the personal supervision of Mr. Poate, owe their existence to the energy and foresight of King Manuel, who has not only devoted his valuable time to those at Shep-

herd's Bush but has also superintended the erection of similar ones in other orthopaedic centres throughout the United Kingdom. The men working are employed as follows:

Employments in Curative Workshops.

Splint makers, smiths, engineers	...	...	25
Carpenters	...	...	10
Tailors (abdominal belts, surgical slings)	...	...	8
Bootmakers (surgical boots, repairs)	...	...	5
Fretworkers (men with dropped feet)	...	...	3
Leatherworkers (blocked leather splints)	...	...	4
Electricians, plumbers, and ironworkers	...	...	7
Masons (repairs in hospital)	...	...	2
Grindery (instruments used in operating theatres)	...	...	2
Wood choppers (sawing and chopping firewood for use of hospital)	...	...	9
Cigarette makers	...	...	7
Office and stores	...	...	4
Draughtsman	...	...	1
Orderlies and fatigue party (errands between different departments, keeping yard and shops clean, taking completed work to different wards)	...	...	11
Painters (painting splints and general work in hospital)	...	...	8
Total	...	...	106

In addition to this special work, over 300 have occupations allotted to them.

FIG. 10.—Interior of department for electro-therapeutics.

Return showing Number and Value of Splints Made in Orthopaedic Workshops.

Week ending—			£	s.	d.
October 28th, 1916	...	36	...	5	3 0
November 4th	...	49	...	7	14 6
" 11th	...	75	...	17	3 9
" 18th	...	64	...	9	11 6
" 25th	...	86	...	12	9 0
December 2nd	...	21	...	11	2 6
" 9th	...	23	...	13	16 0
" 16th	...	67	...	14	18 0
" 23rd	...	26	...	14	11 6
" 30th	...	29	...	8	19 0
January 6th, 1917	...	43	...	12	8 0
" 13th	...	70	...	20	12 0
" 20th	...	55	...	19	1 0
" 27th	...	133	...	34	0 0
February 3rd	...	122	...	27	9 0
" 10th	...	91	...	30	0 0
" 17th	...	55	...	19	17 6
" 24th	...	81	...	17	16 6
March 3rd	...	106	...	31	4 6
" 10th	...	139	...	34	4 2
Totals	...	1,371	...	£362	1 5

Total number of splints made from October 28th to March 10th, 1,371.

Cash value at pre-war prices, £362 ls. 5d.

Of the above returns 1,013 are stock pattern splints, namely, cock-up splints, gutters, club-foot shoes, crab (long and short), Turner's arm, whole hand-splints. The balance (358) are special splints designed in workshops, and made to surgeons' instructions.

Quantity of Orthopaedic Repairs by the Bootmaker.

The total number of cases requiring orthopaedic repairs by the bootmaker from October 21st, 1916, to March 4th, 1917, was 361. This was apart from ordinary repairs. The work consisted of inside and outside elevations, T-straps, cork soles, bars on soles, crooked heels, surgical boots and alterations according to medical orders.

Painting, Drawing, Photographic Department.

This department is under the control of Mr. Bird, the distinguished artist, who is assisted in photography by Mr. Lewis. Here not only photographs and drawings of cases during the various stages of treatment and splints used are made, but actual paintings in natural colour whenever the surgeon thinks it necessary. In this way can be kept complete records of operation cases, which are especially valuable in demonstration for teaching purposes.

X Rays.

This department is fully equipped with all the latest methods for x-ray photography under the supervision of Captain Keys-Wells, R.A.M.C., who attends the hospital daily.

Plaster Department.

This is under the charge of Sister Hurch, formerly of St. Bartholomew's Hospital, who has, as chief assistant, Private Wilde. Casts are made of all deformities admitted and permanent records can be kept of cases before and after operation. In addition to plaster jackets for support and plaster splints, casts are made of limbs and other parts on which splints, both leather and steel, are moulded so as to ensure accurate fitting when finished.

Artificial Limbs.

In association with the question of military orthopaedics it is important to remember that at Roehampton Hospital for Limbless Soldiers all cases of amputation are being provided with suitable artificial limbs at the expense of the State.

I am largely indebted for information relating to the Shepherd's Bush Hospital to the courtesy and assistance of Major Jenkins, R.A.M.C., Officer in Charge, Captain Hill, R.A.M.C., Registrar, and Mr. Poate, Director of Workshops.

The medical staff is to be congratulated in having converted within a week what was formerly an infirmary into a modern orthopaedic hospital.

REFERENCES.

- ¹ The Collected Works of Sir H. Davy. Edited by his brother, John Davy, F.R.S.
- ² The Collected Papers of Baron Lister, vol. ii.
- ³ Transactions of the American Orthopaedic Association, 1891.
- ⁴ The Works of John Hunter. Edited by Palmer.
- ⁵ Anatomy of the Human Body. John and Charles Bell.
- ⁶ Phil. Trans. Royal Society, 1835.
- ⁷ Position of Sir C. Bell among Anatomists. Lecture delivered by Professor Keith at Middlesex Hospital, January 19th, 1911.
- ⁸ Review of Arterial Man, by G. Elliot Smith, Nature, February, 1917.
- ⁹ Effective Treatment of Hip Disease, F. B. Bennie, 1907.

Observations

ON

THE PATHOLOGY OF CARDIAC DROPSY.

BEING THE OLIVER-SHARPEY LECTURES DELIVERED
BEFORE THE ROYAL COLLEGE OF PHYSICIANS
OF LONDON, MAY, 1917.

BY

CHARLES BOLTON, M.D., D.Sc.LOND., F.R.C.P.LOND.,
PHYSICIAN TO UNIVERSITY COLLEGE HOSPITAL; LATE DIRECTOR
OF PATHOLOGICAL STUDIES AND RESEARCH, UNIVERSITY
COLLEGE HOSPITAL MEDICAL SCHOOL.

(Abridged.)

LECTURE II.

We have now to consider the question of the abnormal exchange of fluid between the blood capillaries and the tissue spaces, which leads to an excess of tissue fluid in the congested area, to a deficiency in other parts, and to an increase in the total blood volume.

Absorption in Area of Superior Vena Cava.

It has been shown that when the inferior vena cava is obstructed the venous pressure in the fore part of the body falls, owing to abstraction of blood from this region, and also that at all stages of the disease this pressure is still below normal. The circulatory conditions in this part are, therefore, such as to determine a continuous absorption of fluid by the capillaries from the tissue spaces. It is not to be supposed that absorption is the only process occurring in this region, but that a new balance has been struck between lymph production and absorption. Exactly how this condition is brought about is not known, except that the low capillary pressure is a factor in the process of absorption.

Starling was the first observer to show that proteins are able to exert a definite though small osmotic pressure. In the case of the proteins of the blood plasma he found this pressure to be about 30 mm. Hg as compared with isotonic salt solution. The protein concentration of the extravascular fluid is a quarter or a third of that of the blood plasma, so that the latter is able to exert a definite osmotic attraction for the extravascular fluid. The force of this attraction, as I have already mentioned, is about equal to the hydrostatic pressure in the capillaries, so that when the latter falls below the normal level water will be absorbed.

Absorption in Area of Inferior Vena Cava.

Turning now to the consideration of the exchange of fluid in the area drained by the inferior vena cava our task is not so simple. I have so far assumed that increased absorption is occurring at the periphery as in the fore part of the body.

This question of absorption at the periphery can be examined experimentally, because the parietal peritoneum, which is included in this region, is particularly suitable for such experiments.

With regard to the visceral peritoneum, it is quite clear that output has overbalanced absorption, so that in order to find out what is happening in the case of the parietal peritoneum, we must inquire into the relative parts played by these two processes in the peritoneum generally during the various stages at which the fluid is accumulating, remaining stationary, or disappearing.

Output into Peritoneal Cavity.

Our inquiry into the subject must first be directed to the relative rates of output of fluid into the peritoneum at the different periods of the disease. I shall show later that absorption from the peritoneum is occurring always at the same rate, so that a comparison of the rates at which the ascites reaccumulates after the abdomen has been thoroughly emptied should give us the required information. For this purpose the animal was anaesthetized and the abdomen opened under aseptic precautions. The fluid was then removed with a graduated pipette and the abdomen closed. I found that, however large or small the amount of fluid removed, and whatever the stage of the disease, the ascitic fluid had reaccumulated on the next day.