posterior support, whether a gutter-shaped metal splint, or perforated zinc, or merely webbing slings, must be tightened up if this occurs.

Within twelve to twenty-four hours it will be found that the extension straps are no longer taut—not because they have slipped or stretched to any extent, as is proved by the tape measure, but because the muscles have relaxed. If the surgeon merely tightens the extension straps he finds that he has gained a quarter of an inch or more. In all ordinary cases of simple or even compound fracture, by merely taking up the slack of the extension straps—hand-taut—two or three times a day, it is possible to extend the limb to half an inch beyond the length of its fellow. In civil practice this is what I have always aimed at.

There is no constant extending force put on the muscles, they are merely prevented from contracting. In twenty-four hours at most the nerve muscle apparatus acquiesces in this and no further reflex actions occur; on the contrary, the whole nerve muscle reflex system goes to sleep, the muscles relax and do not remain on guard, as the system of fixed extension has relieved them of all responsibility for the guard against adventitious movement.

The contrary is the case when weight and pulley or elastic extension is used. The nerve muscle system is now kept awake; sudden movements of the patient's body are liable to cause "starting pains" due to sudden reflex contractions. The only means of stopping this is to increase the weight, putting a constant tension on the tissues; but, as Mr. Hey Groves rightly points out, "the less tension there is on the tissues . . . the better the natural resistance of the soft parts against inflammation."

It is on those grounds that I hold that "fixed extension" is physiologically preferable to any method of applying constant extending force, and results show that it is efficient.

When Mr. Hey Groves states, with regard to treatment of cases on the Thomas splint, that he "has never yet seen one in which gross displacement had been corrected by it," he must be speaking from a limited, and possibly unfortunate, experience of the splint. His statement could be contradicted by any surgeon who, at any time during the past thirty years or more, has visited the clinics in Liverpool or elsewhere where the splint is regularly used.

Cases in which malunion has already occurred fall into two classes—civilian and military. In civilian surgery we have been in the habit of interfering with impunity, in cases of compound fracture, very shortly after wounds have closed. In military surgery the danger of recrudescence of virulent infections latent in the wound is so great that an interval of many months must be left after the last sinus has closed. A year ago I regarded three months as a reasonable interval; now I am doubtful if six months is always safe.

It is therefore all the more important, in the case of gunshot fractures, that full restitution of form should be made in the first instance, when the whole area of the fracture is easily manipulated; if malunion is permitted, it may be more than twelve months before it is safe to attempt to correct the mistake.

In civilian practice one has frequently been called on to deal with shortening of $2\frac{1}{2}$ in. to 3 in. two, three, or four months after the injury. In most such cases one can confidently promise to reduce the shortening to $\frac{1}{2}$ in., and often completely. The malunion has to be broken down before the limb can be lengthened. In many instances the fracture can be disunited even several months after the original injury by manipulation only, without having recourse to osteotomy. The guiding symptom as to the possibility of doing this is tenderness at the seat of malunion, for callus which is still tender is rarely very firm.

The difficulty begins after the fracture has been disunited, for the soft parts must be stretched. The method I employ is active extension with block and tackle. This is led through the ring of the Thomas splint, so that when the maximum extension considered advisable at one sitting has been obtained the splint is slipped up the limb and the extension straps secured. It is to be noted that when the block and tackle extension is removed the limb relaxes a little, as it is impossible to tie the straps by

hand to the bottom of the splint quite as tight as the limb can be pulled by block and tackle. This is really the salvation of the situation, as it relieves the tissues of severe tension which if continued would be injurious. From this time on the case is treated as an ordinary recent fracture, unless it is considered necessary to give an anaesthetic again after a week to pull the limb still further down.

It is clear that the cases of malunion brought to the orthopaedic surgeon in civil life following simple fracture or an ordinary compound fracture are seldom associated with the massive cicatrization of all the tissues of the thigh found in cases of compound gunshot injury associated with extensive laceration of the tissues and still more extensive fibrosis the result of septic infiltration of the tissues. In civil cases full correction of a shortening of $2\frac{1}{2}$ inches or more is frequently obtained by these means three or four months after the injury. In military cases associated with very extensive infiltration of the tissues it is necessary to wait about twelve months after the injury, and prognosis must necessarily be more guarded.

The relative value of bone grafts and plates is too big a question to discuss here. Personally I have not put metal of any kind into bone for about ten years. My impression is that metal is physiologically a deterrent to rapid and strong osteogenesis and repair of bone. My training has been to treat fractures by manipulation, and recent experience, during which I have seen many cases of non-union after plating, even in cases in which there is no history of sepsis following the operation, inclines me to the view that plating is an operation requiring a high degree of technical care and skill—a degree of skill attained by Lane and some of his school, but not by all his followers.

The question is whether it is more easy to train a surgeon to be an efficient master of manipulative treatment of fractures on splints or to be a master of Lane's technique in treatment by plating. My own view is that it is easier for a man to become competent in the former, and this course has the advantage of being applicable alike to the septic compound fracture and the simple fracture, while plating to be really successful must be performed in the aseptic case only.

THE TREATMENT OF CONVALESCENT SOLDIERS BY PHYSICAL MEANS.*

BY

MAJOR R. TAIT MCKENZIE, R.A.M.C.

A GREAT military hospital may be compared to a general post office in which the sick and wounded from the front are sorted out into first, second, and third class matter.

The first class matter is distributed rapidly to regular military hospitals and those under the Red Cross, where an operation, or a short course of treatment, puts them right, and after ten days' leave they go back to the fighting line, with few exceptions.

The second class matter requires an additional stay at a convalescent hospital, commanded by an officer of the Royal Army Medical Corps, in which they receive treatment by physical means, including exercise in addition to the usual hospital treatment, and a large proportion of these men again find their way to the front.

The third class matter, however—the cases too tedious for the hospital and the convalescent camp—are more difficult to provide for and dispose of. During the first year of the war they were referred from dépôt to dépôt, always finding that they were at the wrong address, and it was not until last autumn that the Director-General was able to give his attention to these cases that had begun to accumulate in considerable numbers. He arranged a series of command dépôts, commanded by a combatant officer for discipline, with medical officers attached, and to them have been sent all for whom there was some hope of cure, or improvement, within a period of six months.

The objects of these dépôts were to return every available man to active service by treatment; to return men fit for light service abroad who could replace fit men in

* Read before the Section of Surgery of the Royal Society of Medicine, July 21st, 1916.

light duties on lines of communication; to fill positions requiring light duty at home by men who were unable to do anything more than to release a better man for active service; and to discharge from the army those for whom no treatment could be expected to give further results.

These command dépôts afforded welcome relief to the various regimental dépôts and other places overcrowded with men useless from the military standpoint, and of but little use to themselves—men who were rapidly lapsing

FIG. 1.—Machine for exercising the fingers. First position. Fingers extended. Movement, flexion at the metacarpo-phalangeal joints. Movement represented by dotted lines. (Weights in ounces.)

into complete or semi-invalidism, and whose deterioration from a military standpoint was even greater, under the combined influence of sympathy and freedom from all duty.

Either two or four thousand men constitute the complement of patients for a command dépôt—a strange assemblage of cases.

Profound neurasthenia, the result of sleepless nights and arduous days; shock in all its forms—tremulous hands and tongue, stammering speech or deafness, persistent nightmares and fears by day; disorders of sensation, contractures, and paralyses; rapid and weak heart action, hearts that were overstrained and that are unable to sustain the effort of the lightest gymnastic exercise or the shortest march; rheumatism, real and unreal, in all its forms; lungs suffering from the bronchitis of gas poisoning, asthma, and even tuberculosis; profound debilities following typhoid fever, dysentery, and malaria, requiring months of good food, light duty, and progressive exercise to build them up.

An endless stream of the wounded—feet and legs pierced by bullets or pitted by shrapnel; arms and hands with torn nerves and jagged tender scars; chests still containing bullets or pieces of shell—in fact, no part of the body escapes the effects of the ordeal through which they had gone.

For almost all these cases the treatment comes under what might be called “physical therapy,” electricity, hydrotherapy, massage, mechanotherapy, corrective exercises, physical training, and marching.

The electrical equipment consists of the three currents usually supplied by the polystat.

The faradic, used largely in diagnosis of nerve injury, in the treatment of functional conditions of the heart, and for the stimulation of wasted muscles. By the use of the condenser the current is rhythmically interrupted and varied in intensity, and a good substitute for exercise is obtained where movements cannot be made.

The galvanic current, transmitted through water in the Schnee arm and leg baths, is useful for weakened limbs, for certain cases of frostbite and other conditions of impaired circulation, and for the softening of scar tissue by ionization with sodium chloride and potassium iodide solu-

FIG. 2.—Machine for exercising the fingers. Second position. Movement, flexion of the interphalangeal joints. Movement shown by dotted lines.

tions. The ordinary electrodes do not serve for these cases, and we have used copper wire mesh, cut to fit the front of the thigh, the back of the leg, or any other special region; they are covered with felt after the terminals have been soldered on, and are inexpensive.

The sinusoidal current, less irritating than the faradic current, is of value in keeping up the nutrition of muscles whose nerve supply is defective.

The Committee on Balneology of the Royal Society of Medicine gave the War Office the benefit of their experience in planning an ideal equipment for hydrotherapy, by which the ordinary hut is turned into a complete

hydro, with the douche, tub bath, a pool and whirlpool baths.¹

The stimulating douche, hot and cold, has been of use, not only in the treatment, but also in the diagnosis of the many cases of rheumatism, two or three treatments sometimes being sufficient to cause an apparently confirmed cripple to declare himself quite able to undertake full physical training, other cases where the diagnosis was not in doubt, being progressively improved. Many of these cases are treated daily in the tub bath—fifteen to twenty minutes with the temperature at 98°, followed by general massage. A pool is kept at a constant subthermal temperature, about 94°. It is large enough to contain twelve men sitting up

to their neck in water, in which they remain for an hour, and there is a constant succession of patients. It is now applied as a routine treatment for practically all cases suffering from shock and disordered heart action. Under its influence a rapid and excited pulse goes down, and an hour's rest continues this sedative effect.

In the whirlpool bath, limbs with painful scars or frost-bitten feet are submerged in water up to 110°, violently agitated by a continuous flow from two or three jets, or, still better, by a turbine in the bottom. The introduction of compressed air into the stream turns it into a bubbling

FIG. 3.—Machine for exercising the fingers. Third position: (a) Extension of the metacarpo-phalangeal joints; (b) flexion of interphalangeal joints with the extension of metacarpo-phalangeal joints.

and effervescent envelope for the painful arm or leg. It enables one to apply more heat and stimulation with water at a lower temperature than would be possible if the water were still. After twenty minutes' immersion, the whole part is flushed with blood, the pale limb and purple scar

FIG. 4.—Wrist machine, No. 1. Beginning of flexion of the wrist. At the end of flexion the roller is held in position by the ratchet, seen at the left. The handle on the right is for pronation and supination.

become crimson and comfortable, and the circulation remains heightened for hours. It makes an ideal preparation for the necessary massage and manipulation that would not be tolerated without it.

water, so that the heat must be applied in a dry form. For this the radiant light baths are designed, and need not be complicated or expensive. We have found the small hinged shoulder appliance with six lights fulfils all the requirements. It can be adjusted to any single joint at will, and a row of three or four can be placed over the back from the hip to neck, covered by a blanket, and in twenty minutes the whole region so covered will be flushed and reddened, making an excellent preparation for the massage that usually follows. In the great majority of cases at a command dépôt electricity, hydrotherapy, and radiant light are but preparations for massage.

In many cases, however, it is not advisable to have a scar sodden by water, so that the heat must be applied in a dry form. For this the radiant light baths are designed, and need not be complicated or expensive. We have found the small hinged shoulder appliance with six lights fulfils all the requirements. It can be adjusted to any single joint at will, and a row of three or four can be placed over the back from the hip to neck, covered by a blanket, and in twenty minutes the whole region so covered will be flushed and reddened, making an excellent preparation for the massage that usually follows. In the great majority of cases at a command dépôt electricity, hydrotherapy, and radiant light are but preparations for massage.

The Almeric Paget Massage Corps has supplied trained masseuses, one operator being able to treat 20 cases a day, and recently the corps has been strengthened by the first graduates from St. Dunstan's—four men blinded in action and taught their profession since the beginning of the war. The histories of cases neglected for months, or maltreated by unskilled amateurs, shows the imperative necessity for careful training in this most important work.

Many cases come in with limbs which have become wasted and joints stiffened by long immobility in splints, cases which must be slowly coaxed back to strength and usefulness by skilled massage and manipulation.

As massage progresses it is followed by passive manipulation, either by the hand of the operator or by machines designed to stretch shortened ligaments, break down slight adhesions, and restore the normal movement in joints.

The Zander machines for passive movement, owing to their cost, are quite beyond the reach of any but the very few. They are unnecessarily complicated, but substitutes giving the same movements have been designed which will produce the same effects at a cost of as many shillings as the Zander machines cost pounds. Circumduction of the shoulder, with increasing range both active and passive, is given by one inexpensive machine made of two uprights of wood, one with crutch-like support for the shoulder, and the other having attached to it an arm with movable weights, the two connected by a rod grasped by the patient, and capable of being moved out or in at the will of the operator. By it we can

FIG. 5.—Wrist machine, No. 2. An undergrip for extension of the wrist.

progressively increase the range of movement in the shoulder; another acts on the wrist, and still another on the ankle. Treatment must, however, not stop at passive manipulation. The muscles and joints must be systematically re-educated to take up again their normal movements, and again the expensive and cumbersome Zander machine can be replaced by simple devices to strengthen

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FIG. 6.—Machine for wrist circumduction. The arm is strapped in position, the hand grasping the handle rotates the wheel. The extent of movement is governed by a scale marked in inches.

enfeebled muscles by giving them definite tasks of increasing difficulty.

Specially designed machines are now in use at Heaton Park in which the principle of the weight and pulley is employed. Flexion and extension of the fingers at the metacarpo-phalangeal joints and at the interphalangeal joints can be obtained by one (Figs. 1, 2, and 3) having a wire hoop with rings through which cords are threaded and attached to a cotton glove by one end, the other end terminating in rings to which are hung shot bags weighing 2, 4, 6, and 8 oz., so that the muscles can be given an increasing load as they become stronger. The direction of the pull is changed so as to obtain flexion or extension by adjusting the hoop. Other devices are used for the wrist (Figs. 4, 5, and 6), elbow, shoulder (Fig. 7), trunk, thigh, leg, and ankle (Fig. 8), but to be effective movements on them must be given with great accuracy and in known doses. It is easy to mistake the real action that has been performed on one of these machines, the normal action of a stiffened wrist is simulated by lifting the elbow, and what looks like pronation may be in reality a rotation of the shoulder. Many cases of functional paralysis in men who have been crushed or buried have been treated successfully by these means, one extreme

FIG. 7.—Machine for circumduction of the shoulder. The patient is strapped to the upright bearing the crutch support for the shoulder, the arm is extended along the lever and rotates the two weights. This can be either an active or a passive movement.

case of paralysis of the abdominal muscles making a quick and complete recovery.

When a patient is able to perform these movements he must be thrown still more on his own resources by free gymnastics in which there is no guidance from the

machine or operator, and cases are then sent to the gymnastic instructor, who begins with three tables of carefully compiled exercises, starting with half an hour's repetition of such simple movements as raising the heels, turning the head, and bending the arms and trunk, going over the body region by region in a definite progression. Here the wounded man is joined by cases of shock who are able to do only the lightest exercise, by men whose neurasthenia, enteric, or dysentery has left them profoundly debilitated, and slowly they progress through this light physical training from stage to stage until they are able to march in quick time, to bend and twist, and use their arms freely. When they are able to do all these movements they are promoted to full physical training, which introduces quick and active movements, running, jumping, and gymnastic games teaching alertness, control, and agility; walking balanced on raised beams, or lifting their feet high as they go through wire entanglements, climbing walls and leaping ditches. Parallel with this course goes graduated walking on level and then on hilly ground, starting with a mile or two at the patient's own pace, and even with the help of a stick, progressing to three or four miles, and graduating finally into the full route march at quick time.

The patient who can do his full physical training and full route march is ready for the final stage of hardening in which he does the full table of exercises required of

FIG. 8.—Machine for circumduction of the ankle. The patient is seated with the foot strapped to the foot-piece. The movement of flexion and extension is given at the joint between the foot-piece and the wooden upright. A movement of eversion and inversion is given between the wooden upright and the gas pipe into which it is inserted. The foot-piece is attached to a crank coming from a shaft which supports a heavy fly-wheel. This is driven by a flexible driving rod terminating in a handle which is turned by the patient himself, or by the operator. The extent of the movement is determined by the length of the crank that receives the foot-piece.

the trained soldier, and a twelve or fifteen miles march in full kit. This test is necessary, for sometimes it is only when the kit is put on that the healed scar or old fracture becomes painful.

Many cases of disordered heart action can be brought up to the full physical training but not into it. After the first day of it their pulse, which has been brought down to a normal of 80 by faradism or subthermal baths and rest, and which remains undisturbed after a gentle slow walk, jumps up to 120 or 140, and can only be reduced by a reduction of the amount of work required. Several cases were brought up to this point on three or four occasions and had to be returned to lighter duty. Not more than 30 per cent. succeeded in passing into Class A. This experience has also been shared by some cases of shock, and bronchitis following exposure to gas is frequently re-awakened by the forced effort of running or jumping, and many cases of frostbite that are quite able to walk a mile or two find themselves unequal to a forced march, and have to be left on light duty.

We shall in future be able to refer suitable cases to the special hospitals now in course of organization for the treatment of different orthopaedic cases, obscure and puzzling nervous conditions, and for the thorough and minute study of the heart, where individual attention can be paid to cases that would otherwise have to be taken in groups.

A glance at the final result obtained in a command dépôt will, I think, show how thoroughly justified the Director-

General has been in establishing them in spite of the difficulties met with in manning and equipping these great camps.

At Heaton Park an analysis of all classified cases sent out up to date shows that out of all men discharged,

Nearly 50 per cent. have been rendered fit for active service, and have rejoined their units in the fighting line.

About 15 per cent. have been sent to lines of communication abroad.

About 15 per cent. have been sent to useful work of a sedentary character at home; and

Over 20 per cent. have been discharged as permanently unfit, many of these being untreatable from the first.

The average time of each man spent in treatment was well under three months, and the fact must not be lost sight of that, even though a man is not sent back in category "A," his opportunities for a useful career in civil life after the war have been enormously increased and the burden on the nation in future pensions correspondingly lightened.

Note.—I wish here to acknowledge the assistance of Captain A. E. Barclay, R.A.M.C., whose help in time, ideas, and money made it possible to make the experimental machines for corrective exercises, and to thank Dr. H. J. Seuwen for notes on cases under his immediate charge for electric treatment, and Dr. Frank Ratcliffe for special and valuable assistance in observing cases under treatment by hydrotherapy.

REFERENCE.

¹ BRITISH MEDICAL JOURNAL, 1916, vol. i, p. 319.

TRISMUS DURING SERUM SICKNESS (SEPTIC FINGER).

By R. F. BOLT, M.R.C.S., L.R.C.P.,
CAPTAIN R.A.M.C.(T.C.).

As the occurrence of trismus fourteen days after the infliction of a wound is calculated to give rise to great anxiety, not to say alarm, I think the following case may be of interest.

An officer of the Royal Army Medical Corps, doing duty at a casualty clearing station, pricked his right index finger on March 1st while operating on a case of empyema the result of a gunshot wound of the chest. On the following day his temperature rose to 102° F., and the finger was incised. On March 3rd a dose of 18 c.cm. of antistreptococcus serum was injected into the right flank. No antitetanic serum was injected. In the evening his temperature rose to 104° F. On the next day the temperature was 102° F., and it fell to normal on the following day.

On March 7th he was transferred to a general hospital, where he came under my care. On admission the wound in the finger was healed. There was a tender enlarged gland in the right axilla. The temperature was normal and remained so for seven days. The gland subsided. He was up and going about and was marked fit for a convalescent home, but on March 14th an urticarial rash appeared on the arms and chest and abdomen. On March 15th the rash was distributed generally over the body; there was severe headache, and the temperature rose to 100° F.

On the morning of March 16th the temperature rose to 102° F., and he had great pain in the neck, back, and limbs. He complained of stiffness in various muscles; there was also some rigidity, especially in the right upper limb. The lower limbs were drawn up and could not be fully extended. The metacarpo-phalangeal joint of the right middle finger was swollen and very tender. He was given a mixture containing sodium salicylate and sodium bicarbonate, 20 grains of each, to be taken every four hours. There was profuse sweating, the eyes were congested, and the same evening trismus developed; the teeth could only be separated by a quarter of an inch. There was no sore throat and no local inflammatory condition of the jaw or mouth.

The case was seen in consultation by Colonel A. Fullerton, A.M.S., and Major A. E. Webb-Johnson, R.A.M.C. The possibility of the symptoms being due to tetanus was seriously considered, but it was decided that, as the patient was already suffering from serum sickness, it was not advisable to give antitetanic serum, but that other methods of treatment should be tried. Accordingly the patient's room was darkened, and he was kept very quiet. He was given 20 grains of chloral hydrate at 7 p.m., and again at 11 p.m. The pain continued, and he was given $\frac{1}{2}$ grain of morphine at midnight. The sodium salicylate and bicarbonate mixture was continued.

On the morning of March 17th he was a little better; the temperature was 102° F., the trismus was less marked, and the pain was subsiding. Chloral hydrate (20 grains) was repeated every four hours alternately with the sodium salicylate mixture during the day. There was still considerable anxiety as to