REFRESHER COURSE FOR GENERAL PRACTITIONERS**PRINCIPLES OF PHYSICAL MEDICINE—II. THE
USE OF APPARATUS**

BY

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In physical medicine, as in any other specialty, recent years have been marked by continued advances in knowledge and methods, by rejection of outdated ideas and techniques, and by the adoption of newer and more up-to-date therapeutic measures. Scientific scrutiny has been applied to claims made for the various forms of treatment which previously had been supported on the grounds of empiricism and tradition. The statistical method of analysing the results of treatment has been applied and its necessity has been acknowledged. A stimulus to this progressive improvement and advance in apparatus and technique has been the coincident progress made in other scientific fields, especially that of electrophysics. Thus the adaptation of the thermionic valve to the field of therapeutics has revolutionized nearly all types of medical electrical apparatus. Yet, in spite of this great advance in efficiency and accuracy of apparatus, there has been a marked tendency to concentrate much more on the education of the patient to help himself by means of accurately prescribed and carefully co-ordinated voluntary movements, performed either individually or in groups, than to rely on apparatus to produce effects on a patient who is passive.

Our attitude towards the use of electrical energy itself has undergone notable changes. When it was found that the electrical current could be applied to the human body it was assumed by some, as might be expected, that the panacea had been discovered and that such a current was to play a major part in medical therapeutics. The reverse has now been shown to be the case, and the applied electrical current now plays only a minor and insignificant part in treatment. On the other hand the value of electrical energy in producing other forms of energy, such as heat and certain radiations of the electromagnetic spectrum, has been fully appreciated and exploited. When now the patient speaks in all innocence of electrical treatment it is more probable that electricity is being used to produce some form of heat and is not being directly applied.

Apparatus Used in Exercises

In England the value of free voluntary exercise as a remedial procedure has proved itself and has been generally adopted. In most cases very little apparatus is needed for this, but in certain cases the elimination of gravity is desirable, and this has led to the development of exercises in water, in the form of the deep pool, particularly for the treatment of weak limbs of patients suffering from poliomyelitis and also of many arthritics. But pools are by no means universally accessible; therefore the Guthrie-Smith apparatus, wherein a patient can be partially or completely suspended in slings to avoid the effects of gravity, has been designed by a physiotherapist and has been acknowledged as being most

valuable. Again, the best means of obtaining muscular development is to exercise muscle voluntarily against resistance, and this is usually done by some simple device of weights and pulleys, whereby graduated resistance can be applied to the muscle groups which must be strengthened. Similarly, springs can be incorporated in the slings of the Guthrie-Smith suspension apparatus and used to resist the patient's efforts, thus leading to increased muscular strength. It is of interest to note that in America there has been a tendency to produce very elaborate apparatus for what they term "progressive resistance exercises." (Mention must be made of apparatus designed to produce the effects of massage. They are often advertised as being of therapeutic value and as having an effect in reducing weight; neither of these claims can be substantiated.)

Apparatus Used for the Production of Heat

There are numerous ways in which heat can be applied to or produced in the patient's tissues. Some tend to cloak heat treatment in the jargon of mystery and even to ascribe other obscure effects to the physical means employed to produce heat; but it should clearly be understood that such apparatus as radiant heat and infra-red emitters and the various forms of diathermy are used solely to produce heat. Domestic forms of heat applicators should not be neglected—the time-honoured hot-water bottle and kaolin compress are still valuable and effective, as any sufferer knows. Similarly, electric bowl-fires are not to be despised as a source of infra-red irradiation.

Infra-red rays of the electromagnetic spectrum are longer in length than those of the visible spectrum, and the infra-red lamp is usually fitted with a dull or "non-luminous" emitter. On meeting the resistance of the skin the energy of these rays is transformed into heat. These rays do not penetrate further than the skin, and the heat produced is therefore superficial, but is none the less valuable for that. The so-called radiant-heat emitters differ from the infra-red ones in that they also emit a great deal of visible light. Their effect depends entirely on their emission of infra-red rays, but in the case of the radiant-heat lamps there is a greater output of the shorter infra-red rays than from the non-luminous lamps. These shorter infra-red rays are more penetrating and more stimulating to the skin, but it is doubtful if the increased degree of penetration is of any practical importance. Both luminous and non-luminous emitters which are supplied for therapeutic purposes owe much of their superiority over domestic forms of apparatus to the reflectors which are fitted to them and which cause the rays to be evenly distributed over a fixed area.

Diathermy entails the production of heat in the patient's own tissues. In short-wave diathermy, sometimes also known as ultra-short-wave diathermy, the

tissues to be treated are placed in a condenser field and a very rapid oscillation of the electrons in them is obtained by means of thermionic valves in the apparatus. The apparatus generates radio waves of about seven-metre wavelength. This causes the tissues to be treated evenly at all depths; thus a hip-joint or inflammatory focus in the pelvis can be directly heated. In skilled hands, therefore, it is a very valuable method of employing therapeutic heat. In long-wave diathermy an actual alternating current is passed through the tissues. This current changes its phase about a million times in a second. The passage of current takes too short a time to stimulate directly sensory nerves or excitable tissues, but the resistance offered to it leads to the production of heat. This heating is not even but is directly proportional to the resistance offered by the various tissues, and, as such tissues as skin, fat, and bone offer a higher resistance than tissues such as muscle, they are heated to a greater degree. Long-wave diathermy can therefore be a useful means of heating the deep structures of an arthritic joint.

A comparison of short-wave and long-wave diathermy shows that in the former the technique is relatively simple and convenient, as electrodes do not have to be applied in contact with the skin in order to obtain satisfactory deep heat. On the other hand short-wave diathermy apparatus is more costly and has a shorter life than that of long-wave diathermy. There is no doubt that although long-wave diathermy has the disadvantage of needing skilled and exact application of electrodes, which must be bandaged to the part, it does produce a satisfactory deep heat, and some authorities regard it as having definite advantages in certain ophthalmological and arthritic conditions. It is worth noting that in America use is being made of "micro-wave" diathermy or ultra-ultra-short waves; the apparatus generates radio waves measured in centimetres. This produces comparatively superficial heat. This method has not established itself to any extent in England, as it is felt that by correct placing of electrodes both superficial and deep heat can be obtained with the standard short-wave diathermy set.

Dangers.—All forms of heat therapy have the potential danger of causing burns if excessive heat is used. In such forms of superficial heat as infra-red radiations and radiant heat the danger is not great because of the presence of heat-appreciating nerve endings in the skin and because the skin is exposed to view throughout the treatment. In short-wave diathermy heat can be produced deeply in areas where there is no appreciation of heat, and deep burns may be caused if care is not taken; similarly, in long-wave diathermy the skin is usually covered with bandages and the operator cannot watch the skin while treatment is in progress. The potential danger of burns must always be remembered, and it is customary to test skin sensation before treatment is begun.

Paraffin-wax Baths

Paraffin-wax baths are being used more and more frequently as a form of heat therapy for the extremities. This method differs from those already described by being essentially a form of moist heat. Paraffin-wax with a melting point between 115 and 120° F. (46.1 and 48.9° C.) is melted and applied either by dipping the part into the wax or by painting it on with a brush. The wax is left on for twenty minutes to half an hour. The heat of the wax causes a vasodilatation and hyperaemia

with sweating. But the superimposed wax prevents the sweat from evaporating, and heat is not lost, thus more sweat is secreted and the skin becomes moist and pliable. After removal of the wax it is customary to exercise the affected part actively. The potential danger of paraffin-wax baths is that the paraffin may catch fire; precautions have to be taken against this.

Muscle Stimulation

Muscle can be artificially stimulated to contract by electrical excitation. But no such statement should be allowed to pass unqualified without making it perfectly clear that the best way to ensure healthily contracting muscle is by active voluntary exercise, either with or without resistance, rather than by passive stimulation by an electrical current. The traditional currents used in muscle stimulation are the faradic and the interrupted galvanic or constant. The faradic current is easily generated from small cells in the apparatus commonly known as the Smart-Bristow coil; it can also be obtained from a switchboard by modification of the mains current. In more modern apparatus it is obtained by modification of the mains current by means of thermionic valves. This current is essentially a low-frequency alternating current of low voltage, one phase of which stimulates the muscle to contract through its motor nerve. Thus an intact motor nerve is essential. It is usually applied in the "surged" form, in which the intensity is raised from zero and a tetanic contraction is excited and relaxed. Its main use is to re-educate muscles that are too weak for the patient usefully to contract, or, as in the case of the intrinsic muscles of the foot, when the patient has forgotten how to use them. It should always be used in conjunction with voluntary contraction.

An interrupted direct current will stimulate muscle directly without the necessity for the presence of an intact nerve supply. It is therefore used in maintaining the contractibility of muscle which has temporarily lost its nerve supply, as in injury to motor nerves. It is this differentiation between the response to the faradic and interrupted galvanic currents that governs the traditional test for the muscle whose nerve supply has degenerated, leading to the reaction of degeneration.

The modern apparatus for muscle stimulation employs thermionic valves to produce electrical impulses, the duration, frequency, and intensity of which can all be varied. Such "balanced pulse" stimulators can be used for treatment but are also of great diagnostic value, as a day-to-day record can be kept of the response of affected muscle to stimuli of varying length, strength, and frequency.

The Direct Current

This is also known as the constant and the galvanic current. Like the faradic and sinusoidal currents (see below) it can be obtained from a combined switchboard, in which the mains current is stepped down and suitably modified to produce a constant current which can be passed through the tissues; it can also be obtained from a battery. The effect of passing such a current of low amperage through the tissues is to cause a dissociation of the ions of the tissue salt solutions with a deposition of acid and alkali under the electrodes. It is claimed to cause hyperaemia and counter-irritation: the cathode is said to be stimulating and the anode soothing. Such a current is also claimed to be of value in reducing

oedema. But it is important to realize that these claims are not generally acknowledged by the medical profession as a whole, and that such treatment is prescribed only by a small proportion of practising doctors. An inherent danger in the use of the direct current lies in destruction of the superficial tissue by the deposition of acid and alkali under the electrodes, the so-called "galvanic burn." Thus pads have to be used beneath the electrodes to prevent this, and great care has to be taken to ensure correct technique.

The direct current can be used to introduce substances into the tissues by the process of ion transfer or ionization. A great number of substances can be introduced in this way and there once was a vogue for the introduction of such "antirheumatic" drugs as the salicylates and potassium iodide by these means. This form of treatment is losing popularity, and the main substances now introduced by ionization are histamine and drugs with similar properties, which cause local vasodilatation. General reactions may occur after the introduction of histamine and great care has to be taken in treatment.

The caustic effects found at the electrodes when the direct current is used are sometimes employed for the destruction of small naevi. A needle electrode is a satisfactory method of removing unwanted hair.

Sinusoidal Current

The sinusoidal current is a low-frequency alternating current, but it differs from the faradic in stimulating at both its phases. It is often applied by means of baths, and as, like the faradic current, it produces a tetanic contraction of muscle it is usually surged. It is claimed that sinusoidal baths assist in stimulating peripheral circulation by causing a pumping action of muscles and by causing vasodilatation of the skin. This current is losing popularity and is not often prescribed.

Ultra-violet Radiations

These rays of the electromagnetic spectrum are shorter than those of the visible spectrum. They are most commonly produced by arcing a current across carbon electrodes, in which case the open flame of the carbon arc emits an intense heat and light in addition to some ultra-violet rays, or by the passage of a current through ionized mercury in a quartz tube, the so-called mercury-vapour lamp. Ultra-violet rays have many physical, chemical, and physiological properties.

The carbon-arc and the mercury-vapour lamp can be used for general irradiation, in which case the longer ultra-violet rays play the greater part. These cause a delayed erythema of the skin, which is followed, after repeated exposure, by tanning due to the deposition of melanin. An overdose can cause a severe "sunburn." The claims for the value of general ultra-violet irradiation seem exaggerated. There is no scientific evidence that they prevent infection and reduce susceptibility to colds. Small amounts of vitamin D are certainly produced in the skin under their influence, but the treatment of vitamin-D deficiency is to give this by mouth, not indirectly through ultra-violet irradiation. There is no doubt, however, that general ultra-violet irradiation has a traditional reputation for having tonic properties, and it remains popular probably for its psychological effects.

Local application of ultra-violet irradiations is usually carried out by means of a mercury-vapour burner which

is water-cooled. Use is made of the shorter and more destructive wavelengths, and so powerful are these rays that considerable superficial destruction of the skin can be achieved by application of the burner for a matter of a few seconds. This can produce a powerful counter-irritation as well as destroy and sterilize the surface of such lesions as indolent ulcers. The local application of ultra-violet irradiations is specific in the treatment of lupus vulgaris, and when it was evolved by Finsen it revolutionized the treatment of this condition. The situation has been somewhat modified recently by the use of calciferol. Local ultra-violet irradiation is of value in a large group of dermatological conditions.

Obsolescent Apparatus

In the process of medical evolution once-popular remedies frequently lose their popularity and become forgotten. Thus in physiotherapy departments one may still see high-frequency effluve machines by which the skin was once electrically stimulated; similarly static machines may be preserved as museum pieces which show how in the old days patients were suitably impressed by being treated with static shocks. Unreasonable support of discredited remedies has no place in modern medicine, and these pieces of apparatus are best forgotten.

New Treatments

New forms of apparatus are being evolved and await trial before their value can be assessed. One of these—the micro-wave diathermy machine—has already been mentioned. Recently much literature has appeared on the use of ultrasonics as a therapeutic agency. Sound waves beyond the frequencies which stimulate the human ear can be produced by the phenomenon of piezo electricity. Claims have been made that these are of value in a truly surprising range of conditions. This enthusiasm for a possible new remedy is a familiar phenomenon, but at the time of writing the value of ultrasonics remains unproved.

Addressing the Reading Pathological Society, Sir Robert Hutchison recalled the hospital atmosphere of 50 years ago (see the *London Hospital Gazette*, October, 1951). The thing that would most strike modern doctors if they were able to visit a hospital run as it was then would be the simplicity of the methods of diagnosis. The history would first be read out by the clerk—"often not a very literary production. (When I see correspondence in the *B.M.J.* complaining of the illiteracy of the present-day student I remember how much of my time was spent in correcting spelling and grammar 50 years ago. Students were always illiterate—but so were many members of the staff.)" Then the patient would be examined, and the clerk would give the results of some elementary tests—presence or absence of sugar or albumin in the urine, for instance—and that was about all: no reports, because there was no material for them; x rays had only just begun and were used only for fractures and simple surgical injuries; barium meals did not exist; and "there were no biochemical reports (happily!), because there were no biochemists." In 1900 it cost about £115,000 a year to run the London Hospital, and 50 years later it cost about £1,200,000. Sir Robert added that he did not believe that the hospital was now doing 10 times more good to the community; inflation brought about by two world wars was partly responsible, but the main reason was the present inflated staffs—both lay and medical. To-day the average stay of a patient in the London is 18 days; in the early part of the century it was only 13.