The march : its mechanism, effects and hygiene / by Patrick Hehir.

THE MARCH

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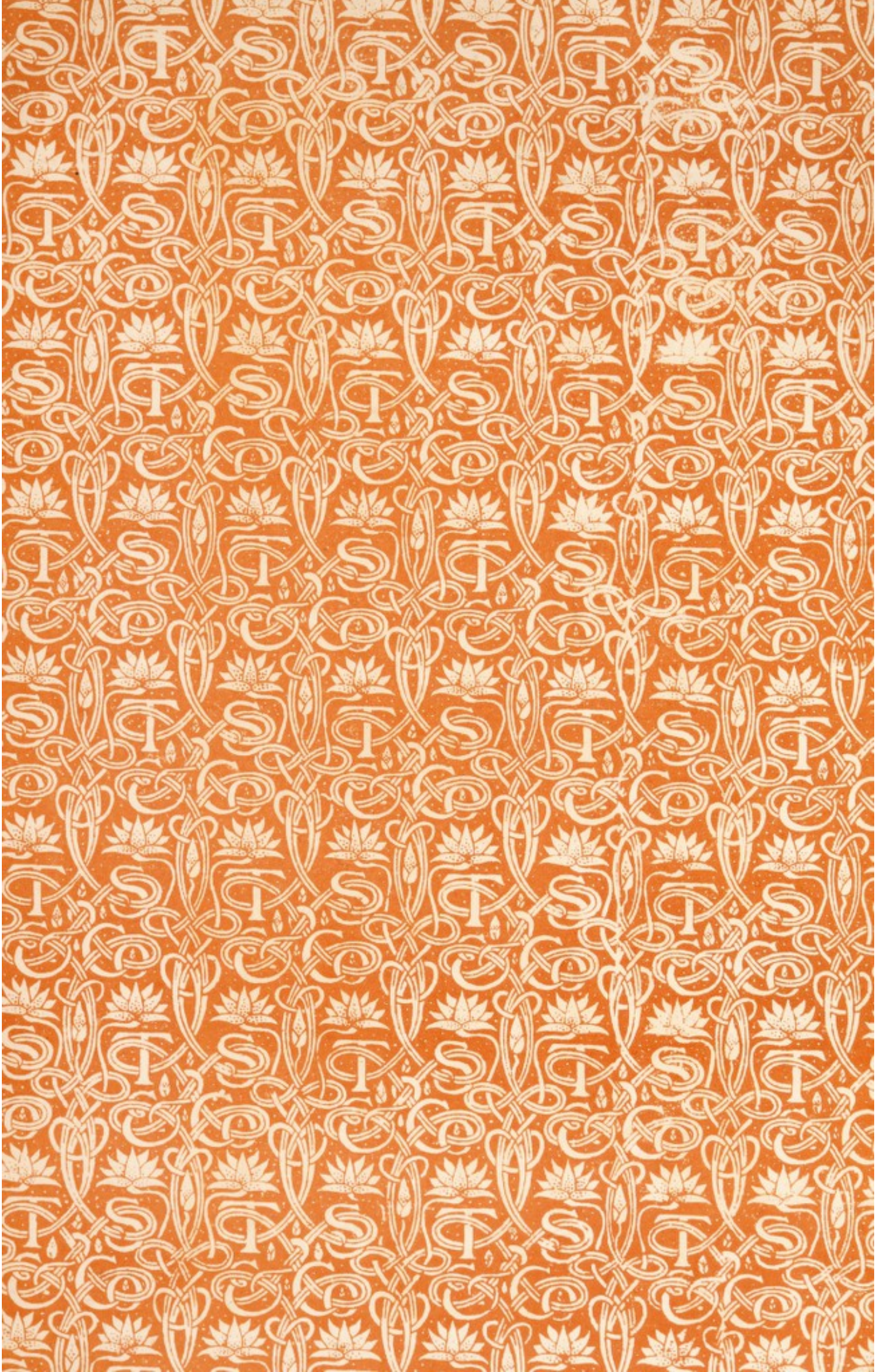
MECHANISM, EFFECTS

AND

HYGIENE

Lieut.-Col. PATRICK HEHIR, I.M.S



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BY THE SAME AUTHOR.

Prevention of Disease and Inefficiency with Special Reference to Indian Frontier Warfare. Illustrated, Second Edition, pp. 640 (*Pioneer*, Allahabad).

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Moral, Physical and Social Effects of Alcohol.—Two Lectures. Second Edition, pp. 65 (*Lawrence Asylum Press*, Madras).

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BY

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PREFACE.

The following pages formed the subject of two lectures given to the officers of the Lansdowne Garrison in 1909, 1910 and 1911. Several friends have been generous enough to express the opinion that these lectures would serve a useful purpose if published for a wider military audience, and in deference to this opinion they are sent forth in their present form.

The scope of the original lectures has been somewhat extended and certain amendments have been made.

P. H.

Lansdowne,

January 1912.

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THE MARCH: ITS MECHANISM, EFFECTS AND HYGIENE.

PART I.—MECHANISM AND EFFECTS OF THE MARCH.

INTRODUCTION.

MARCHING is by far the most important of all military exercises. A soldier who cannot march is a useless incumbrance on field service. The soldier must be able to march with his full equipment long distances at any pace ordered by the commander. He must be able to do this without any inordinate fatigue, and at the end of a march he should have enough residual energy to take part in an engagement, and, if necessary, follow up a successful attack on an enemy.

"If it be an incontrovertible truth that the efficiency of strategic formations depends upon the manner in which they are accomplished, if it be true that modern warfare entails on infantry increasing marching and counter-marching, if it be true, consequently, that only those most fitted for marching are the armies which have the best chances of victory, then the army which is least capable of marching (no matter what that incapacity arises from) is already condemned beforehand to defeat, however well armed it be. Rational marching are the *alpha* and *omega* of the infantry."* This remark was originally made with reference to footsoreness and damaged feet from various causes, but it applies equally well to all conditions which incapacitate infantry from marching "By far the most important factor affecting the efficiency of troops for war is their power of marching. The march is the keystone of all operations, and the success of every undertaking depends very largely on the accuracy of the arrangements made for its performance. In many case the arrival of a body of troops at the right place, at the right time, and in good fighting trim, may be the decisive factor in the situation."† A capacity to endure long marches then forms a constant and essential part of the soldier's training. No other function taxes his powers of endurance more, or when not in fit condition, has a greater effect in lessening his resistance. It is a function which must be developed. Thorough

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* Dr. KLEFBERG quoted in the *Journal of the Royal Army Medical Corps* June 1906.

† *Field Service Regulations*, German Army, § 303, 1900 edition; quoted by Lt.-Col. C. H. MELVILLE in the *Physiology of the March*.

efficiency in every other branch of his profession is of little use to the infantry soldier if he is unable to march under field service conditions.

It is on record that at home in the autumn manœuvres of 1895, in one division 835 men fell out on the march. Since then it has been usual to practice marching regularly and systematically, gradually working men up from 8 or 9 miles to 15, with an occasional 20-mile march. At the end of the manœuvres the men should be able to do 100 miles in six days without any special strain, and without men falling out as the result of the marching itself. "In the practice marches of the French Army the recruit commences at the distance of 16 kilometres and this is gradually increased to 30 kilometres. Finally, he is given four successive days marching under the full equipment, the distances being 22, 24, 26 and 28 kilometres. With the French recruit after some training roads are abandoned and the command is marched over country. The course of training in vogue in the German and Russian Armies is something similar to that of the French."*

To enable us to properly comprehend the mechanism and effects of marching, how it affects resisting power and endurance, and how it may be made a means of storing physical energy, improving stamina and of producing all the beneficial effects of healthy exercise, it is necessary that we should briefly review the physiological effects of muscular exercise in general and those of walking under the special conditions of military life in particular.

Organs of the Circulation and Respiration, and the Skin.

Before considering that part of the physical development of the soldier that concerns us here, it may be advisable to make a few remarks regarding the organs of the circulation and respiration; the structure and function of the skin in its relation to the regulation of temperature; the structure and functions of muscles; and the meteorological conditions that affect the marching capacity of troops. These will only be alluded to so far as is necessary to elucidate what happens in the circulatory, respiratory and cutaneous systems during marching.

Circulation of the blood.—In a healthy man at rest the heart beats about 72 times a minute, and at each beat throws a certain amount of blood into the arteries. We may deal with the circulation under two headings—*the greater* or *systemic*, or the course of the blood through the body; and the *lesser* or *pulmonary*, or course of the blood through the lungs.

The greater circulation.—From the left auricle the blood is forced past one of the valves opening into the left ventricle (mitral valve); thence it is driven through the semilunar valves into the great aorta, which is the main trunk of the arterial system of vessels. Passing

* Munson's *Military Hygiene*, pp. 64, 65.

through the arteries, capillaries and veins, it returns through two large veins, called the *venæ cavæ* (ascending and descending), gathers again

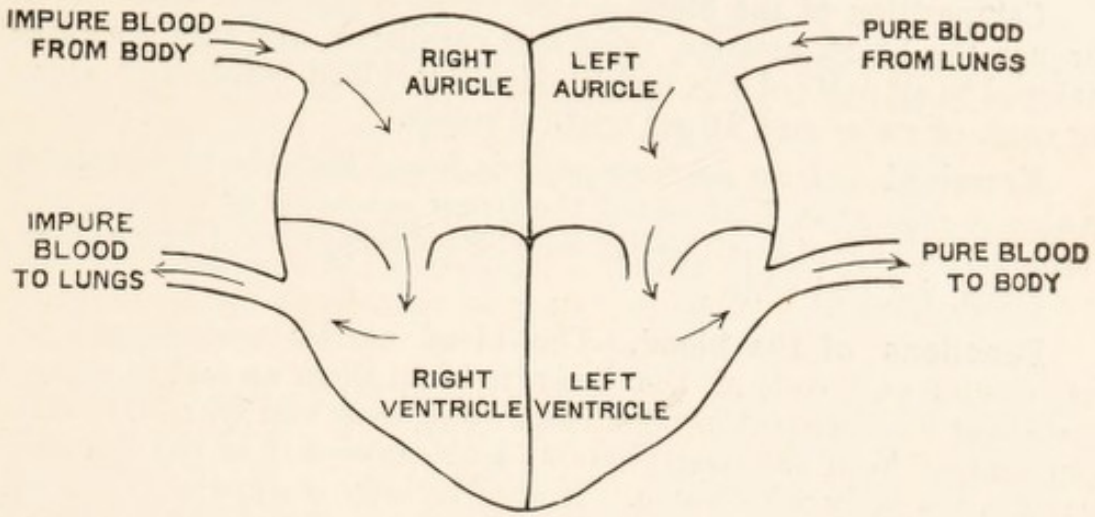

Diagram of Heart.

in the right auricle and so completes the round of the body. Both the greater and lesser circulations are going on constantly—as the auricles contract, the ventricles expand simultaneously, and *vice versâ*.

In the capillaries the flow is very slow, giving time for the nourishing fluid with its oxygen to ooze through their walls into the tissues. This stage in the greater circulation is that which is intimately connected with nutrition and the chemical activities of muscles during marching and all other active exercises. At the same time the waste products from the tissues are taken up by the blood, and completely change the quality and appearance of the blood, which has now been deprived of oxygen and much of its nutritive material.

The lesser circulation.—The dark blood from the veins collects in the right auricle, and going through one of the valves (tricuspid) on the right side of the heart, empties into the right ventricle. Thence it is driven past the semilunar valves, through the pulmonary artery, to the lungs. After circulating through the fine capillaries of the air-cells it is returned, bright and red, through the four pulmonary veins to the left side of the heart (left auricle).

How the blood is purified.—The blood is purified in three ways :—(1) By passing through the blood vessels of the lungs, where it gets rid of carbonic acid gas (the result of the oxidation of carbonaceous or heat-producing substances in the tissues and organs of the body), and excess of water in the form of vapour ; (2) by passing through the vessels surrounding the sweat glands under the surface of the skin, where it gets rid of excess of water (in the form of perspiration), a small quantity of carbonic acid gas and a little urea (the result of destruction of nitrogenous or tissue forming substances) ; and (3) by passing through the blood vessels of the kidneys, where

it gives up excess of water with a large proportion of urea and a little uric acid, both these latter being held in solution in the urine.

Composition of the blood.—The blood is the fluid that circulates through the heart, arteries, veins and capillaries, and supplies nutritive material to all parts of the body. Healthy blood consists of about 79 per cent. of water and 21 per cent. of solids.

Examined under a microscope, it is found that the blood consists of an almost colourless fluid called the *liquor sanguinis* or *plasma*, and an enormous number of small bodies called *blood corpuscles* of which there are two kinds, red and white.

Functions of the blood.—The blood carries nourishment to all the tissues and cells of the body to build them up and to repair the waste that has occurred in them from work, wear and tear. It absorbs nourishment from the food-products and conveys it to the tissues. It provides the body with water. It absorbs large quautities of oxygen in the lungs and carries it to all parts of the body. This is effected by the red cells. Oxygen is necessary for the working of all tissues and cells. In this working the oxygen is consumed or slowly burnt up. This combustion produces heat and energy. In doing so waste products are formed, which, if allowed to remain in the body, would be harmful. The tissues and cells are largely composed of C, O, H and N, and in the process of combustion the C and O unite to form CO_2, the H and O combine to form H_2O. The blood is also the means by which all the waste products are taken away from the body, carrying these to the excretory organs—kidneys, lungs, and skin. The constant oxidation going on in the body produces a large amount of heat ; the blood acts like the hot-water pipes used for heating houses, and distributes this heat uniformly throughout the body. The blood produces all the materials required for forming certain secretions or juices in digestion—from it the cells of the salivary glands secrete saliva, the glands of the stomach secrete gastric juice, the liver forms bile, and so on.

The organs of the circulation must be properly trained before their powers of endurance and their capacity are severely taxed.

Respiration or breathing.—Both the mouth and the nose are lined by a highly vascular mucous membrane so that air passing through them is warmed and moistened before it enters the lungs. The air should naturally be conveyed to the lungs through the nose, and not through the mouth. The bones within the nose, called the *turbinated bones*, are so arranged that they act as a filter ; and the nasal cavity being largely supplied with blood vessels, in cold weather the nose warms the air before it gets into the lungs.

By breathing, we cause the air to enter and leave the chest. The air is conveyed into and from the lungs through the windpipe. Each respiration consists of two acts—*inspiration*, or taking air into the chest ; and *expiration*, or expelling it.

Inspiration.—When we draw in a full breath, we unconsciously straighten the spine and fix the head and shoulders, so that the muscles that expand the chest may act to the greatest advantage. At the same time, the *diaphragm** descends and presses the walls of the *abdomen* outwards. By these means the size of the chest is increased and the elastic lungs expand to occupy the extra space, while the air rushes in along the windpipe and bronchial tubes, and reaches the air-sacs.

Expiration.—If we expel the air from the chest, the operation is reversed : We draw in the abdominal walls, and the diaphragm ascends ; all, together, lessening the size of the chest cavity and sending the air from the lungs.

Mechanism of respiration.—The blood in the lungs is constantly absorbing O and giving up CO_2 in exchange. To effect this the air in the air-cells of the lungs has to be constantly renewed. The mechanism of respiration teaches us the method by which this is carried out. The cavity of the chest is a closed air-tight chamber connected with the external air by the windpipe. The pressure of the air in the lungs keeps the lungs stretched and in contact with the chest walls. The contraction of the diaphragm causes the lungs to be pulled down and the cavity of the chest to be enlarged. When the diaphragm relaxes, the size of the chest is lessened. The up and down movements of the diaphragm are the chief movements of ordinary breathing. The chest is also enlarged by the ribs being raised by certain of the muscles between the ribs (the intercostal muscles). One set of these contract and pull up the ribs which are fastened behind to the spinal column and (those of the upper seven ribs) to the breast-plate in front. When the ribs are raised, they push the breast-plate out or forwards in front. This latter enlargement occurs at the same time that the diaphragm contracts, so that the thorax is enlarged on all sides. A certain quantity of air then rushes into the lungs—these two actions represent *inspiration*.

Immediately following inspiration the diaphragm relaxes and ascends, and at the same time another set of intercostal muscles begin to pull the ribs and breast-plate down. These combined movements, together with the natural elastic recoil of the lungs, diminish the cavity of the chest, and consequently the same quantity of air is driven out of the chest that entered during inspiration. This is *expiration*. The lungs are highly elastic, expand with inspiration and recoil in expiration. Between inspiration and expiration there is a short pause.

The inspiratory part of ordinary quiet breathing is performed mainly by the diaphragm, and the expiratory part by the elastic recoil of the chest walls and lung tissue. A healthy man when at rest breathes about 15 to 18 times a minute.

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* The broad muscular partition between the thoracic and the abdominal cavities.

The actual quantity of air drawn into the lungs at each inspiration varies according to constitution, build of chest, and other circumstances. In an adult it is about 25 to 30 cubic inches and it may be said that in an ordinary inspiration without any effort an adult inspires about a pint of air; by practice, however, as much as 9¼ pints of air have been inhaled.

Capacity of the lungs.—The full capacity of the lungs of an adult man of 5 feet 8 inches in height is about 330 cubic inches. As just stated, at each ordinary inspiration about 25 to 30 cubic inches of air enter the lungs. This is called *tidal air*. After each ordinary respiration about 200 cubic inches of air remain in the lungs—this is termed *stationary air*. By a deep expiration about 100 of these 200 cubic inches can be expelled—this 100 is called *supplemental air*. The remaining 100 cubic inches is called *residual air*—this cannot be expelled. By taking a deep inspiration 100 cubic inches can be added to the stationary air (making the full capacity to 330 cubic inches); this extra 100 cubic inches is called *complemental air*.

If we take a deep inspiration and then forcibly exhale all the air we can expel from the lungs, this amount, which is called the *breathing capacity* or *vital capacity* of the lungs, will bear a close correspondence to the stature. For a man of 5 feet 8 inches in height it will be 230 cubic inches or about a gallon, and, for each inch of height between 5 feet 6 inches and 6 feet there will be an increase of 8 cubic inches. As above stated, another 100 cubic inches can be forced into the lungs by an extra effort, and is available for emergencies, or for purposes of training, as in marching, doubling, running, climbing, etc. This is of great importance, since, if the capacity of the lungs only equalled our momentary wants, the least obstruction to breathing would be dangerous to life.

The capacity of the chest is important in estimating the fitness of a recruit. The heart and lungs, which represent the staying power of a soldier, are of great significance. Mobility of the chest is in this respect an important point to record—especially with reference to the height and weight. Free mobility of the chest is usually associated with the other main factor in the lungs—capacity.

Chest and lungs.—The condition of the chest and lungs is perhaps one of the most important points in the physique of the soldier. Their development necessarily includes that of other parts of the body, for we cannot perfect the capacity of the lungs, bony frame and muscles of the chest without also developing the back, loins, limbs and their muscles. A capacious chest with good expansion is usually associated with well-formed limbs.

Composition of inspired and expired air.—Air is composed of a mechanical mixture of oxygen and nitrogen. It always contains a few other agents, of which the chief are—carbonic acid gas, watery vapour, and particles of mineral substances and of dead and living organised matter.

In the human body the oxygen sustains combustion and supports life by combining with and oxidising the tissues, and so producing heat; the nitrogen dilutes the oxygen which by itself would act too rapidly on the substances with which it comes into contact; the carbonic acid gas is the result of the oxidation of oxidisable material in the tissues and cells of the body. No change occurs in the nitrogen.

Let us contrast ordinary air with the air given off from the lungs :—

	Inspired air.	*Expired air.*
	Volume per cent.	Volume per cent.
Oxygen ..	21 ..	.. 16·5
Nitrogen ..	79 ..	.. 79
Carbonic acid gas	·04 ..	.. 4·5
Watery vapour	Variable ..	.. Saturated.
Organic matter	Absent ..	.. Present.

Air which has passed through the lungs contains from 16 to 17 per cent. of oxygen and 4 or 5 per cent. of carbonic acid gas. We see that the air in passing through the lungs loses 4 to 5 parts of oxygen and gains 4 to 5 parts of carbonic acid gas. Expired air contains about 100 times as much carbonic acid gas as inspired air. Through it a man in 24 hours sends off from his lungs as much carbon as is contained in a piece of charcoal weighing eight ounces—the carbon is in combination with the invisible CO_2. Air leaving the lungs is about 98° F., no matter what the temperature of that entering it.

Watery vapour.—An adult, in 24 hours, gives off from 9 to 11 ounces of water from the lungs. This quantity is considerably increased during active exercise, such as marching, doubling and running. In the cold weather we can see clouds of steam coming from the mouth. This visible vapour is water in a finely divided state. We can also prove that this watery vapour leaves the mouth by breathing on to the front of a looking-glass. By doing this we notice that the mirror is dimmed and becomes damp directly. The air we inhale contains a small and variable amount of water, but the air we exhale is *saturated* with watery vapour.

Effects of Indian climate on respiration of Europeans.—As regards the European in India, the following has been shown. The capacity of the chest for air is greater in India than in Europe, the increase amounting to from 7 to 8 per cent. This is due to the fact that the lungs contain less blood and hence more room for air. The frequency of the respirations is decreased, and the respiratory act is as a whole lessened. Although the chest capacity is greater, the diminished respirations more than counter-balance it, and moreover, heated air contains less oxygen per cubic foot, which further reduces the total consumption. The elimin-

ation of carbonic acid gas is decreased because the amount thrown off bears a ratio to the quantity of air inspired (see pp. 13, 14).

Structure of the skin.—The skin is composed of a *superficial* and a *deep layer*. The superficial layer is called the *cuticle*, *epidermis* or *scarf skin*, and is that part which is raised by a *blister*, or when boiling water falls on it. The *deep layer*, called also the *dermis*, *cutis vera* or *true skin*, is made up of nerves and blood vessels bound together by an elastic and fibre-like tissue having also in its structure involuntary muscular fibres. The superficial layer, on the other hand, is bloodless, and when damaged does not give rise to pain, nor does it feel heat or cold.

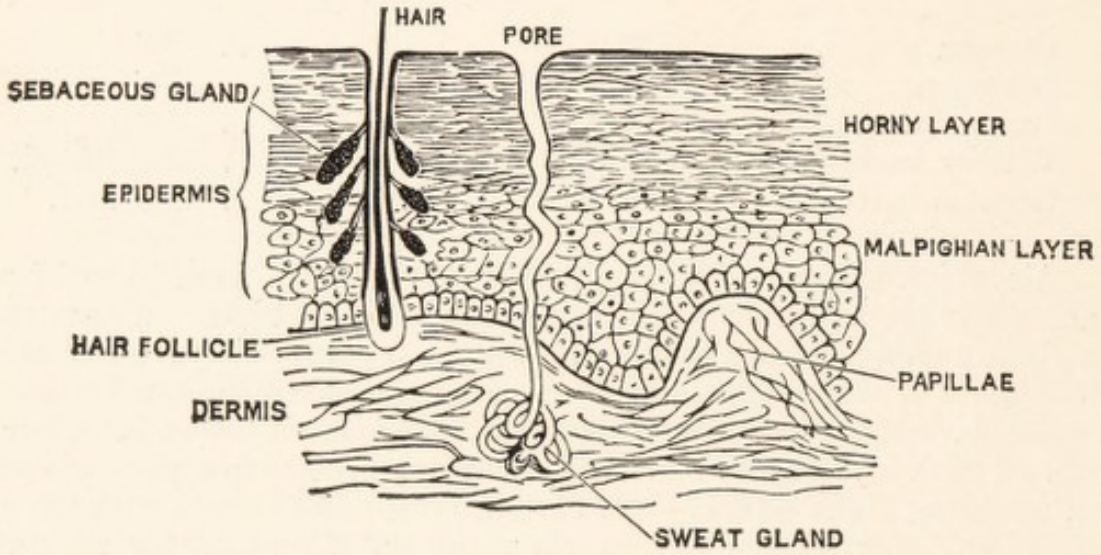

DIAGRAM OF SKIN.

Sweat glands.—Beneath the true skin are situated the roots of the hair and two sets of glands—one which secretes the sweat, and the other (sebaceous glands) which secretes an oily substance that serves to keep the skin soft and the hair from becoming too brittle. The sweat glands, also called *sudoriferous* glands (from the Latin word *sudor*, sweat), are surrounded at their deeper parts by a large number of minute blood vessels, from which they take that which is required to form sweat. Each gland consists of a minute tube, which at its deeper end coils up and forms a small spherical body called the *glomerulus*, and from this passes a wavy narrow tube (the *duct* of the gland). These tubes open on the surface of the body by minute orifices, commonly called the "pores of the skin." About two-and-a-half millions of these little pores are found on the skin of the body. Sweat is always being secreted. Sometimes it is formed so rapidly that it may be seen to ooze from the skin, this is called *sensible* perspiration, but when we are cool and the amount of perspiration formed is small, we do not notice it, for it soaks into the horny layer of the skin and keeps it moist. This latter is called the *insensible* perspiration; it is constantly being evaporated from the surface of the body. As the sweat glands are constantly at work and

driving waste materials from the blood, it is very essential that we should keep their openings free by cleanliness of the skin.

Sweat.—Sweat itself consists of a transparent colourless fluid holding in solution certain fats and volatile fatty acids, urea, free lactic acid, salt, chloride of potassium and other bodies.

Functions of the skin.—The skin is one of the most important organs of the body. One of its special functions is that of excretion—it gets rid of a certain amount of poisonous material from the blood; this is effected by the sweat glands. The skin of an adult throws off about 20 ounces of water daily, but this quantity varies with the season of the year, nature of the climate, work done, occupation, etc. In the hot weather and during severe exercise, for instance, this quantity may be lost by the skin in an hour or less. But sweat is not all water. It contains solid poisonous waste matters, which, if not washed off from time to time, decompose on the surface of the body. The skin further, by a complicated mechanism, serves to regulate the temperature of the body. It forms a sensitive covering for the whole body, protecting the deeper parts from injury. It also plays the part of a sensient surface for the reception of sensory impressions. The skin is capable of absorbing certain bodies from the surface; the lead poisoning which occasionally occurs in house painters and printers is due to this. The ship-wrecked sailor in a boat in the open sea soaks his clothes in the sea and puts them on to assuage his thirst. Small abrasions on the surface permit of various bacteria gaining access to the system, and this is one of the ways in which certain infectious diseases and blood poisonings are produced.

The skin as a regulator of temperature.—Heat is lost from the body by being given off to the air by evaporation of the sweat, and by convection, conduction and radiation. Radiation, however, is not an important source of loss of heat except in the cold weather, as it takes place very slowly and is comparatively small in amount. If the skin were covered by an impermeable varnish, loss by radiation would take place very rapidly, and animals so treated die from loss of heat. Heat is used up by the evaporation of the sweat and in marching this is important. A large amount of heat is requred for the conversion of water to the gaseous state, and as the air surrounding the body is a bad conductor, most of this heat must be supplied by the warm surface of the body itself. As there is a close network of capillary blood vessels lying immediately below the surface of the skin, the blood in these becomes cooled; and this, on its return to the heart, lungs and interior of the body, causes a general lowering of temperature throughout the body. The whole of this mechanism of heat regulation is under the control of the nervous system which acts (1) upon the blood vessels, and (2) upon the sweat glands. Under normal conditions the two sets of nerves going to these structures work together, but they may act independently; in some cases of fever this takes place, as when we have a flushed face with a very

hot dry skin, or in collapse, when we have a bloodless skin with profuse perspiration. The heat of the body is practically always the same, summer and winter. The internal temperature of the glass-blower and the engine-stoker, who work before furnaces, is not higher than that of other people, because the heat-regulating mechanism of the body enables them to throw off the heat by perspiration and evaporation from the surface. Charbert, "The Fire King," used to go into a hot-air room in which the temperature was 400° F. and remain there for several minutes, yet his temperature did not rise beyond normal. The tissue of the body, especially the muscles, liver and brain, are always producing heat, because in them there is constantly in operation a slow burning or oxidation. Man is able to live in all climates because his blood always keeps at about the same temperature; the Esquimau, who lives in the ice and snow of the North Polar regions, is as warm as the African living under a scorching tropical sun.

The skin of Europeans in India is particularly sensitive to changes of temperature, and this accounts for the great susceptibility to chills. The skin is supplied with a large quantity of blood, and in India there is a greater amount of perspiration and more evaporation from the surface. Any abrupt stopping of perspiration or evaporation is liable to be followed by a chill which may lead to derangement of the bowels, liver, or other internal organs. Chills are responsible for many of the conditions of ill-health occurring in India. It is necessary to clothe ourselves properly so as to keep the surface of the body at a uniform temperature.

A few hygienic considerations regarding clothing.—The chief points in connection with the clothing of the soldier are—that it should be a non-conductor of heat, capable of absorbing moisture, permeable to air and water, and durable. The main objects of clothing are to cover the body and to protect from external influences; these influences are chiefly cold, heat, and damp. Clothes serve to prevent the heat of the body being lost too rapidly, to maintain a uniform or equable temperature on all parts of the surface of the body, to prevent the action of the sun on the skin and body, save the surface of the body from injury, and to keep out rain. Suitable clothing in winter serves to maintain the warmth of the body and to exclude the external cold. In summer, on the other hand, suitable clothes serve to keep the body cool; they should not absorb the rays of the sun, and should permit of the radiation of the heat of the body. The clothing should be capable of absorbing perspiration. We can readily apply these essential conditions to the different kinds of wearing apparel.

Clothing to some extent interferes with *direct* radiation of heat to the surrounding air from our bodies, but a certain amount of radiation to the clothes does take place, and then from the clothes this heat is radiated to the air. Clothes likewise conduct away heat from our bodies. The heat radiated from the clothes will depend on the rapidity with which heat is conducted from the surface of the body. The amount of

conduction and radiation of heat will vary much with the nature of the material and the colour of the clothes. What clothing does is to render the processes of radiation and conduction of heat from the body more even and gradual, and so one of its functions is to prevent the danger that would arise from a sudden change of atmospheric temperature. A warm still air feels warmer to our skin than a moving air of the same temperature, because in the latter case a large quantity of air comes in contact with the skin and removes more heat by increasing evaporation.

Damp and wet clothes should not be worn longer than necessary. If the clothes have been wetted, we should keep moving about actively until they can be changed, or have dried on the body. If possible, after a wetting the wet clothes should be removed, the body rubbed down thoroughly with a rough towel, and warm dry clothes put on ; wet boots and socks should be replaced by dry ones as soon as possible. Damp moist clothes should always be aired and sun-dried before use again.

The best outer garments are those that are light in weight and of grey or *khaki* colour, fit loosely and are washable. Nothing can be said against the *khaki* drill used by our troops in India.

It is a great error to be overburdened with clothes. An excess of clothing renders the body very liable to chills. No part of the clothing should give rise to pressure or constriction. Neither the chest, neck, nor abdomen should be compressed by constrictions of any kind. All clothing of the soldier should fit moderately loose so as to allow freedom of movement in every part of the body, otherwise the mechanical work done in marching, etc., is increased.

Meteorological Conditions affecting Marching.

The two chief meteorological factors affecting marching are—atmospheric temperature and atmospheric humidity.

Atmospheric temperature.—The latitude of a place is the main determining cause of its temperature, although a glance at the isothermal chart of India* will show that this is only true in a general way. The isothermal chart of India shows that the lines are in no way parallel with the zones of latitude. The isothermal line corresponding with the average temperature of India is seen to be very irregular in outline. As a rule, the nearer a locality to the Equator the hotter it is, because the solar rays fall more vertically than in higher and lower latitudes, and the sun's rays have a shorter distance to travel than when more adjacent to the poles.

Regarding the temperature, we should differentiate between *radiant* or *sun heat* and *shade* or *air heat*. The rays of the sun heat the human

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* A map with a series of lines passing through places having corresponding temperatures.

body and everything they fall on, but warm the air through which they pass only slightly. The air would allow the heat to pass through it entirely were it not for the watery vapour and the dust, sand, etc., it contains. The more vapour and other added bodies the air contains, the less powerful is the direct or radiant sun heat. The shade temperature is chiefly due to the warmth imparted to the air from the ground previously heated by the sun's rays. The shade temperature may, however, be greatly influenced by currents of air from distant parts, *viz.*, warm or cold winds.

The heat radiant depends on the direction of the sun's rays, the vertical being hot, the oblique less so. It also depends on the depth of the column of air. At the sea-level this column is deepest. The higher we go from the sea-level, the more rarefied the air becomes, and the less the heat of the air due to solar rays. Heat is also modified by proximity to warm or cold sea currents, large collections of water, rivers, streams, lakes, etc., proximity to mountain ranges, by the nature of the soil, direction of the prevailing winds, relative humidity, amount of vegetation, etc.

It is essential to distinguish between the *effects* of radiated or sun heat and shade heat. It is not possible to state with our present knowledge what actual degree of sun heat can be borne by the body. Sunstroke is rare in the pure and comparatively dry air of high elevations. High shade temperature is less easily borne than a moderately high sun temperature ; people who can work in a sun heat of 130° Fahr. or so, may soon become exhausted with the same work in a shade temperature of 105°—110° Fahr. But this question is complicated by the fact that we are unable to differentiate the effects of temperature *per se*, from those of moisture, electrical state of the air, etc. People tolerate heat very differently, and the manner of living influences their capacity in this respect ; many Europeans living in India injure themselves by continuing to take the same kind and amount of food and stimulants they did at home, a fact pointed out by many great authorities on the military hygiene of India during the last sixty years. It seems, however, that great shade heat continued for long periods has a depressing influence, lessening the functions of digestion, respiration, circulation and blood formation, and directly or indirectly the formation and destruction of tissues.

Atmospheric humidity.—This we refer to under the terms *absolute* and *relative humidity*. *Absolute humidity* is the actual weight of watery vapour in a given quantity of air. When air is heated, it expands, and its capacity for holding vapour increases rapidly. A cubic foot of air at zero Fahrenheit can hold only 0·54 of a gramme of water, at 32° F. 2·13 grammes, at 50° F. about 4 grammes, at 80° F. about 11 grammes, and at 100° F. 19·79 grammes. *Relative humidity* is the amount of watery vapour contained in air relative to what it could contain, the standard maximum being 100 per cent. The lowest relative humidity is said to be 25 per

cent., under 55 per cent. it is said to be dry, under 75 per cent. moderate, over 85 per cent. very damp. Relative humidity is important only when taken into consideration with the temperature, because warm air takes up more watery vapour than cold air.

The degree of the absolute humidity varies with the seasons and at different times of the day ; it is usually greater with higher temperature and *vice versâ*. The variations of relative humidity as a rule follow to some degree the opposite course : the relative humidity is lower in the hot than in the cold weather, and lower during the warmest parts of the day than at night. The importance of temperature should never be forgotten in estimating the value of relative humidity in connection with the effects of climate.

It is difficult to separate the effects of different degrees of air moisture on man from those of temperature, light, atmospheric pressure and movement of air. In dry air the evaporation from the skin and from the lungs is promoted, and this effect is increased, if, at the same time, the sunshine is powerful, as in elevated regions. In moist air both are diminished. In moist warm air the vital energies are lessened.

Of meteorological conditions the degree of relative humidity of the air is that which has most effect on marching. A moderately hot sun with a comparatively dry air can be tolerated with less discomfort than a humid atmosphere, that is, many degrees lower. When men are obliged to march where there is a high atmospheric temperature with a high degree of humidity we almost invariably get cases of heat-syncope (pp. 60, 61) or heat stroke (pp. 57-60) or both.

Changes effected during acclimatisation of Europeans.—The more important of the changes produced on the newly arrived European are :—A greater supply of blood to the surface of the body and a greater activity of the functions of the skin, which, by profuse perspiration, keeps the body at its ordinary temperature ; the adjustment of the system to counterbalance the additional external heat is not completed for some time and until that time is reached, the temperature in the European is slightly higher than normal.* The body heat increases in the proportion of 0·05° F. for every 1° F. of the air. The average temperature of Europeans in Bengal is about 0·41° F. higher than in England, and the average temperature of the native of India is about 0·5° F. higher than that of the European. The blood distribution is modified, especially by its being to some extent transferred to the surface blood vessels. This is chiefly at the expense of the blood in the lungs. The capacity of the lungs is thereby increased to the extent of 23 ounces. This extra space is taken by air ; the lungs do actually less work because the number of respirations per minute is lessened. The air is more rarefied in consequence of its higher temperature and it therefore contains less oxygen,

* W. J. Simpson, C.M.G., *Principles of Tropical Hygiene*, p. 12.

which fact alters the physiological working of the lungs. The result is that about 9 per cent. less oxygen is taken in, and about 20 per cent. less carbonic acid gas and 20 per cent. less watery vapour, are discharged. This causes the retention of carbonaceous matter in the blood. At the same time there is excessive activity on the part of the skin, liver, bowels and spleen. In general terms, however, the effects of the climate is to produce a decrease in the vital activities ; the pulse is slowed, the heart's action slightly weakened, the powers of digestion enfeebled, the appetite decreased, the activity of the liver increased, and nutritive activity lowered. The abdominal organs become abnormally sensitive to external influences. The nervous system is at first stimulated, then slightly depressed, allowing it to be more readily affected by impressions from without.

Exercise in the tropics raises the temperature more immediately and powerfully than it does in temperate climates, and if the temperature is taken after evening exercise (at a time when the normal diurnal physiological maximum is reached), it may show a difference of as much as 1·5° F. or more. The heightened temperature after exercise may be maintained for some hours. A march in the hot sun may raise the temperature several degrees, but this is, as a rule, due merely to the combined effects of exposure to the sun and fatigue, and although the fever thus produced may last a few days, it passes off without any ill effects. The heat-forming part of the heat-regulating mechanism is more easily stimulated in India than in temperate climates by such conditions as exposure to the sun, meals, and exercise.

The entire process of acclimatisation is said to take about four years. It is during this time that diseases peculiar to the soldier in India are more liable to occur, but with moderate care he may keep in good health without suffering from any one of them, granted he was sound in every respect on his arrival in the country. Complete acclimatisation of Europeans, or the power of residing in the country permanently for several consecutive generations does not occur.

"Speaking generally the natives of tropical climates are not injuriously affected by the meteorological conditions of the climates they live in, any more than are the inhabitants of more temperate climates ; their physiological activities are attuned by heredity and habit to the conditions they were born into. The European, it may be on his first coming to the tropics, and until his machinery has adjusted itself to the altered meteorological circumstances, is liable to slight physiological irregularities, and this more especially if he persists in the dietetic habits appropriate to his native land. A predisposition to certain diseases and a tendency to degenerative changes may be brought about in this way, but acute disease, with active tissue change, is not so caused. In the tropics, as in temperate climates, in the European and in the native alike, nearly all disease is of specific origin. It is in their

specific causes that the difference between the diseases of temperate climates and those of tropical climates principally lies."*

On the plains November, December, January, February and March are as a rule the healthiest months as well as the coolest, and it is during them that men can work hard out-of-doors and keep very fit under such work. April, May, and June are as a rule very hot and dry; these are the months to avoid sunstroke. July, August, September (and often part of October) are the rainy season, during which anophelines breed freely and disseminate malaria; they are also the months in which dysentery, diarrhœa and liver complaints are most likely to occur.

Although the Indian climate is warm, especially during several months of the year, one of the greatest dangers the European has to protect himself from is cold—he has not to withstand variations of 30 to 40 degrees in the day in his European home—hence in India a cotton garment worn during the heat of the day may, if kept on till late in the evening when the temperature is many degrees lower, lead to a chill. Chills are acquired in India much more readily than in temperate and cold climates, partly because in such climates we wear suitable clothes, the skin is not so sensitive to alterations of temperature, and partly because the skin in India is unusually sensitive to variations of temperature.

Structure and Functions of Voluntary Muscles.

We move our limbs with the fleshy parts of our body, which are called *muscles;* those which are under our control are called *voluntary muscles.* There are about 500 such muscles in the body, each having its special use, and all working in harmony.

Muscles have the power of contracting or decreasing, and relaxing or increasing in length. The muscles are nearly all arranged in pairs, each muscle having its opponent, so that when they relax and contract alternately, the bones to which they are attached are moved. If we bend up the arm and close the fist firmly, we feel a hard lump in front of the middle of the upper arm. This lump is the biceps muscle which has undergone contraction. If at the same time, we feel the muscles at the back of the arm, we will find it relaxed and soft. There are other muscles over which we have no control, such as that of the heart, and those found in the walls of the intestines and elsewhere; these are called *involuntary muscles;* they have a different structure and innervation to the voluntary muscles and we need not deal with them here.

The voluntary muscles are composed of very fine red fibres, and these fibres of fibrillæ; the fibrillæ are made up of very minute cells, which cells, at their lines of union, give the muscle a striped appearance.

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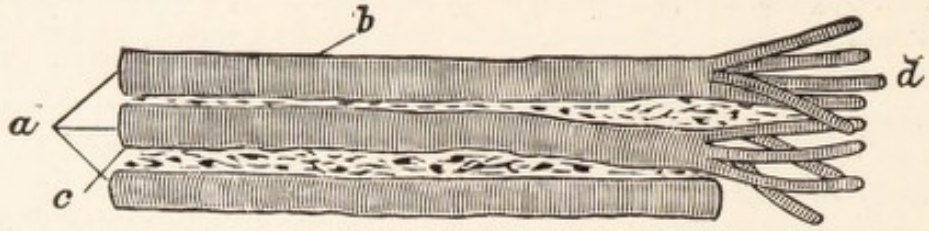
* Sir Patrick Manson, *Tropical Diseases,* 4th Ed., p. xiv.

Hence voluntary muscles are called *striped or striated muscles.* The cells are filled with a living, semi-fluid (protoplasmic) substance. The fibres



Voluntary muscle fibres (*a*), with their component fibrillæ (*d*) teased out, their nuclei (*b*) and covering (*c*).

themselves are bound together in bundles, and the ends of these bundles are usually hard and string-like to fit them to be attached to bone. They usually arise from processes of bone, are usually of an elliptical shape from thickening in the middle, and then gradually becoming narrower and smaller end in white and shining tendons which are generally attached to another process of bone. Muscles by regular use get strong. Want of proper use, or their improper use, causes them to decrease in size. Every part of our body must be properly exercised if we wish to keep healthy. All muscles receive a nerve supply from either the brain or spinal cord.

If a muscle be constantly exercised, its efficiency is increased according to the call made upon it. The absolute force of a muscle, *i.e.*, the weight it is just able to lift, depends upon its cross section or the number of fibres which act together in raising the weight. If, therefore, the strain on a muscle is constantly increased, the muscle tends to grow and increase its cross section. Thus, if it is desired to considerably increase the size of muscles, they are constantly exercised against a force which is greater than that which they have normally to overcome. On the other hand, ordinary exercise does not necessarily increase the size of muscles, for it is well known that many men who are able to march long distances have only small muscles. For the training of the soldier it is not necessary to subject his muscles to any unusual strain. We may conclude, then, that exercise improves the efficiency of a muscle and its power of resisting fatigue, whilst increased strain causes increased size of the muscles. Therefore the arm and leg movements of the Swedish system of training cannot produce developmental effect in the ordinary acceptation of the term, and further, the system as applied to recruits, while it does aim at the *development* of the trunk muscles and harmonious action of the muscles generally, does *not* aim at the *development* of all the muscles of the body.

The normal stimulus that leads to muscular contraction is a nervous impulse which starts at a nerve centre of the brain or spinal cord, and travels down a motor nerve to the muscle. A muscle in contracting becomes shorter and thicker. Fatigue diminishes the amount of contraction of muscles.

When a muscle is at work or contracting, more energetic chemical changes are occurring in it than when it is at rest, more heat is produced and its temperature rises. The chemical changes consist chiefly in an increased consumption of oxygen, an increased output of waste materials, especially CO_2, and an organic acid. Muscle regarded as a machine is sometimes compared to artificial machines like a steam engine. A steam engine is supplied with fuel, the latent energy of which is transformed into work and heat. The carbon of the coal, wood, or oil unites with the O of the air to form CO_2, and it is in this process of combustion or oxidation that heat and work are liberated. Similar though more complicated combustions occur in a contracting muscle. In a steam engine a good deal of fuel is consumed, but there is great economy in the consumption of the living muscular oxidisable material. An ordinary locomotive wastes about 96 per cent. of its available energy as heat, only 4 per cent. being represented as work. In the best triple-expansion steam engine the work done rises to 12·5 per cent. of the total energy. In muscles 18 per cent. of the mechanical energy is available as work, so that a muscle is a little more economical than the best steam engine, but the muscle has this advantage over every steam engine—the heat it produces is not wasted, it is used for keeping up the body temperature. The chemical processes occurring in muscles then lead to a transformation of energy into work and heat. In muscular contraction there is a transformation of the potential energy of chemical affinity into other forms of energy, especially visible movements and heat.

Physiological Effects of Exercise.

As far as we are here concerned, the principal physiological effects of properly regulated exercise are :—

1. Increased frequency and depth of the respirations—the lungs are more expanded, and the air-cells completely refilled with fresh air with each inspiration ; this is associated with increased absorption of oxygen, and greater elimination of CO_2, which latter is produced chiefly by the oxidation of fats in the body and the oxidisable substances in muscles. The demand for more oxygen in the muscles necessitates greatly increased activity on the part of the respiratory organs. These are amongst the greatest of the physiological advantages of exercise. A man marching at the rate of 4 miles an hour inspires five times more air than when lying down.

The CO_2 of the blood is the chief normal agent which acts upon the nerve centres of breathing. The increased quantity of CO_2 in the blood during exercise gives rise to increased stimulation of the nerve centres of respiration, and tends to make the respirations more rapid and deeper, and simultaneously with this there is an increased interchange between the blood in the capillaries of the lungs and the air in the air-cells,—increased respiratory ventilation, so to speak, accelerating blood purification.

2. Increase in the force and frequency of the heart's action by (on an average) about 20 beats per minute, with a subsequent fall in the pulse-rate on discontinuance of exertion to below the normal rate at rest. The blood purified in the lungs is driven all over the body more rapidly during exercise than when we are breathing tranquilly at rest. The waste-matters of the muscles and tissues are removed more rapidly because the blood washes them out of the body more speedily. The extra stimulus to the heart is due to the increased amount of blood brought to its cavities, and the venous circulation supplying this blood is largely influenced by muscular contraction. Every muscle is, in a sort of a way, a little heart, which by its contraction tends constantly to drive the blood more rapidly through their arteries and veins, and thus facilitating its return to the heart and lungs more expeditiously.

3. Increase in the amount of perspiration, with the result that the total amount of water in the body, and especially that in the blood, is diminished by active exercise. The heat lost in the evaporation of the increased sweat from the skin maintains an equability of the body temperature, notwithstanding that heat is more rapidly produced during muscular exertion. As soon as the exercise ceases, the formation of the extra heat is stopped ; the body as a rule rapidly cools and the temperature becomes normal ; after severe and prolonged exertion the temperature may even become subnormal, and in this state the body is very susceptible to chills.

4. The muscles undergo an increase in bulk, firmness and power by regular exercise, representing an increased storage of nitrogenous and oxidisable material.

5. Exercise increases the appetite because (*a*) of the increased demand of the muscles for food, and (*b*) on account of the increased circulation of blood through the liver and vessels of the alimentary tract causing a more rapid assimilation of the food taken. After severe exercise an increased amount of carbonaceous food and of water is indicated to replenish the body and to replace what has been thrown off. The most immediate way of replacing the carbon used up is by the use of such substances as fats, bread, potatoes, rice ; the liquid thrown off is best replaced by water.

The general result of these changes is an improvement and maintenance of the nutrition of the body as a whole, and of the muscles (including the heart) in particular.

During active exercise strain is thrown on the heart, blood-vessels, and lungs, the activities of the circulatory and respiratory systems being largely increased. By accelerating the circulation and respiration the disintegration of worn-out tissues, and removal of effete waste-product is expedited, and the formation of new tissue is facilitated—exercise hastens both waste and repair.

All the voluntary muscles are richly supplied with blood-vessels (which carry blood for their nutrition, repair and storage of reserve material) and with means by which they are brought under the control of the will. They are the mechanical power, the phyiscal vigour of the body.

By the activity of the muscles an impulse is given to the blood going through their arteries and veins, and it is thus forced with increased momentum into the capillaries (see p. 18). Exercise aids digestion, keeps up the function of the liver and intestines, prevents constipation, and helps to use up any excess of proteid material in the circulation. In the absence of exercise the tissues of the body are liable to become soft, flabby and fatty, the muscles waste, and if subjected to any sudden strain or activity, they or their tendons and the structures in and around joints are liable to tear or give way; the heart being a muscle may similarly give way or be greatly disturbed by any sudden or prolonged effort. A man may by a rigidly abstemious diet lead a physically inactive life with exemption from disease, and may even live to old age, but he can never possess all the alacrity of body and exaltation of animal spirits of which his nature is capable, and which make life itself an enjoyment. His circulation must be languid, the waste of material small, and the demand for new supplies of material limited; there is low vitality and a weak digestion.

Heat formed during Exercise.

The formation of heat during muscular exertion is so important a factor in connection with a soldier's marching capacity that it seems desirable to deal with it specially.

During all kinds of active muscular exercise the heat generated is got rid of—by the evaporation of the perspiration, whether it be in visible or invisible drops; by conduction and radiation from the skin (see pp. 9, 10), and by the moisture and heat of the breath. The extent to which the latter may get rid of heat in some animals is seen in the case of the hunting dog whose open mouth and hanging tongue and very rapid breathing get rid of a large amount of heat and moisture. In man the blood is driven in increased quantity to the large area of the skin whence the extra heat of exercise is mainly dissipated.

The more vigorous the contractions of the muscles, the more heat is generated and the sooner fatigue comes on. If we ascend a tower, the work done is that of raising the weight of one's whole body to the top of the tower. If the staircase in the tower has a gentle slope, each step being low, less fatigue is felt than if we ascend the same tower by a smaller number of steps. Much more heat is generated and energy expended by men ascending a hill of say 1,000 feet in height when the ascent is 1 in 10 than when it is 1 in 50, if the speed of marching is the same in both cases (see pp. 30—33).

Muscles contain a body called *glycogen* or animal starch which is elaborated in the liver from the food assimilated. On the contraction of muscles this glycogen is converted into a form of sugar and this sugar (and other bodies), containing C, H, and O, is oxidised during the contraction, its place being taken by a fresh supply.

Muscles become fatigued by (1) using up all the oxidisable material available for the supply of energy in the muscle, and (2) by the effects of the accumulation of the waste-products of combustion. This latter is the more important cause of the fatigue. As a matter of fact, it is usually not the muscles that are fatigued, but the nerve-endings in the muscles or the nerve centres of the brain or spinal cord ; we know from common experience that the state of the nervous system largely influences the state of our feelings as regards fatigue during exercise. This we explain by stating that the fatigue products formed in the muscles during active exercise cause most of their injurious effects by acting on the central nervous system (brain and spinal cord) and diminishing its power of sending out impulses. This is why mental occupation of some sort on the march is one of the safest and surest ways of preventing the sensation of fatigue. For instance, the carrying out of some tactical scheme against an imaginary enemy, without unduly increasing the length and duration of the march, is a profitable way of shortening the march ; for the same reason the music of a band, drums and pipes, bagpipes, and singing and whistling, tend to conquer fatigue (see pp. 22, 45).

It has been experimentally proved that the introduction of the blood of a fatigued animal into the circulation of a fresh normal one will give rise in the latter to symptoms of fatigue (see p. 49).

Weight as affected by Exercise.

The weight during training exercise is a good indication of condition. At the commencement of training weight is lost, especially fat, but it is soon regained by increased muscular development provided the diet is suitable and adequate in quantity. A loss of several pounds during prolonged exercise does not affect the man, provided he is in good condition. The substances chiefly used up or oxidised are the fat of body and glycogen of the muscles. The bodies resulting from the combustion, H_2O and CO_2, are rapidly thrown off by the skin and lungs respectively. The loss in weight is chiefly related to the amount of fuel used up. Hence a man who has a sufficient supply of reserve fuel in the form of fat and glycogen is in a better condition to withstand prolonged exertion than one who is deficient in these substances. In the early part of training there is a loss of weight, while the man is getting rid of superfluous fat, but when a certain point is reached, that which the athlete calls his *weight in training*, any further material reduction is accompanied by a feeling of weakness, lassitude and an incapacity to sustain prolonged exertion without excessive fatigue. This is what is known as "stale-

ness,'' and it is probably due in part at least to the deficiency of the reserve fuel. This indicates the necessity of providing troops in training for marching with a proper proportion of fats and starches in the ration.

Effects of Excessive Exercise.

Excessive exercise produces results which are soon recognisable. If very severe, or if persisted in notwithstanding the warnings of fatigue, other serious consequences may follow. *Locally*, excessive exertion induces first exhaustion of the muscle, then lessened response to stimuli from the brain and spinal cord, and, finally, degeneration; so that an over-used muscle becomes smaller in bulk than normal. These local changes are due to a denial to the muscle of those periods of rest which are requisite for recruiting its expended energy, and for proportionate elimination of its own waste-products. This applies to what we know scientifically of individual muscles experimented on. What is true of an individual muscle may be broadly stated to be true of the whole muscular system, were it subjected to exertion similarly prolonged and repeated without the necessary reliefs.

Exercise may be excessive by reason of its severity, by too frequent repetition at short intervals, or its undue prolongation. These terms are, however, to be considered relative only, as we have no definite fixed standard by which we may judge what excess of exercise really is. It varies with the individual, his capacity for exertion at the time, and the rate at which it is carried out, that is, the time within which it is accomplished, while its effects on the body are directly influenced by external conditions under which it is practised; thus, if active exercise be undertaken in heavy and too closely fitting clothes, just before or after a meal, in an ill-ventilated room, etc., its results must necessarily be injurious. The safest rule for general application is that which insists on the abandonment of the exercise directly moderate exertion has induced a definite feeling of fatigue or signs of respiratory embarrassment. If the fatigue following a day's exercise is entirely removed by a good night's rest, it may be assumed that the exertion has not been excessive, but if the man wakes up feeling tired or exhausted, or insufficiently rested, it is at least certain that he has encroached on his reserve nutrition and that his physiological expenditure has for the time being exceeded his receipts. If the warning given by fatigue is disregarded, sleeplessness is apt to be induced; this fatigue-insomnia is a well-recognised phenomenon. One of the first effects of excessive muscular exertion is laboured breathing with occasional sighing respiration. If too frequently repeated, strenuous exertion may induce enlargement and dilatation of the heart with other possible serious secondary consequences. After too long-continued exertion the number of heart beats instead of returning to below the normal rate continues to be more frequent than normal, and it may be irregular or intermittent. The pulse rate going up to 120—140 per minute and not returning to normal, is a sign of misdirected training.

The immediate ill-effects of strenuous prolonged exercise may be lessened by the drinking of a sufficient quantity of water or other innocent beverage.

Exercise should never be overdone or carried to exhaustion, which may produce reduction of vital force beyond the powers of a man's nutrition and vitality. One day's indiscreet over-exertion may take weeks to recover from. In the case of the weak or diseased, over-exertion is still more injurious by aggravating all the symptoms of feebleness or of the disease. In all forms of exercise, whether in training or not, over-fatigue is specially to be avoided as it renders us liable to lethargic langour, may bring on "fatigue fever," and lower the general resistance of the body to disease causes.

Active exercise should be taken in suitable clothing which ensures free movement of the chest, abdomen and limbs ; *e.g.*, the tunic of the marcher should be loose, and the chest, neck and abdomen uncompressed, the belts and accoutrements should be so arranged as not to hamper either muscular movements or the action of the heart and lungs.

Exercise should be followed wherever practicable by a rapid bath with vigorous friction of the skin with a rough towel.

Alcoholic beverages should be eschewed during exertion since they tend to lessen the throwing off of CO_2, and to deaden the impulses from the brain to the muscles (see pp. 72—74).

Exhaustion.—If the physical training of the soldier for marching is not properly carried out, the condition known as *exhaustion* may supervene during a march, this being a safeguard against over-exertion. Fatigue may be due to lack of sufficient oxidisable material in the muscles to carry out the task required, or to exhaustion of nerve force and the weakening of motor impulses from the brain and spinal cord, and it is to a great extent caused by the accumulation of the waste-products and CO_2 generated in the muscles circulating in the system. The actual sense or feeling of fatigue is not a measure of the actual amount of exhaustion in the muscular system, as under the influence of excitement the fatigued man may carry out physical tasks which previously he considered himself unable to do. The will rarely taxes the muscular system to the full capabilities of the muscles. In a body of men undergoing training the signs of exhaustion are first seen in the poorly-developed, the weak and the young. The symptoms are to some extent similar to those of fever. Muscles undergoing too frequent contraction become painful, and, if the fatigue is great, the pulse is weak.

Over-training.—The usual symptoms of this state are—loss of strength and endurance, so that a man previously strong becomes incapable of prolonged effort. This is associated with a general listlessness, nervous restlessness, a loss of weight, anæmia, and loss of appetite. It is a condition the earlier manifestations of which we occasionally see in regimental hospitals, after severe marches, on manœuvres, and sometimes in recruits in cantonments.

The real cause of the conditions that give rise to the symptoms of over-training have not been properly elucidated by physiologists. In all probability it is seldom due to actual overwork, for the work trained men are called upon to do is usually well below their physical capacity. It may be due to defective diet, absence of oxidisable material in the muscles, dulness of the nerve centres or nervous fatigue from one of many causes, the centres failing to send motor impulses to the muscles, and to other causes, etc.

Training for the March.

Training is necessary in all cases where any severe or long-continued physical effort is to be made, in order that all parts of the body is rendered equal to the task. Graduated exercises have been found of great use in training recruits for military service, but in all cases they require to be properly carried out under skilled supervision. Excessive or violent exercise without previous gradual training, may give rise to serious damage to the heart, lungs and body generally.

The general objects of all physical education is to establish health and a good constitution, and fit the individual for the duties and work of daily life. The physical and special training of the recruit and developed infantry soldier is to a large extent directed towards enabling him to march.

Essentials to be aimed at.—The essential objects to be achieved in the preparation of the soldier for marching are—to progressively increase his reserve of physical capital, to keep adding to the muscular power of his heart, the vital capacity of his lungs, the strength, activity and co-ordinating power of his muscles, and, at the same time, to quicken his intelligence. When these have been accomplished, the soldier is thoroughly trained and fit in every case. Men in this condition of fitness are in every way superior to those less trained—they do not knock under after a forced march, they can go on a smaller allowance of food, bear loss of clothes, vicissitudes of temperature, and withstand exposure; minor ailments and injuries have little effect on their efficiency, and even the more severe wounds, when not in vital parts, heal more rapidly and enable them to return efficient soldiers to the fighting line once more.

Recruits' course of physical exercises and drill.—To effect the development of the present day recruit, he is put through a six-months' course of physical exercises and drills. This early period of a recruit's development is all-important, and in all regiments should be under the careful supervision of the adjutant and medical officer.

Evil effects of misdirected training.—The medical office should specially watch the influence of the training on the circulatory

and respiratory systems of recruits, noting any palpitation or breathlessness, and any cases of rapid wasting. One has seen several regiments in which there were an inordinate number of "heart" cases amongst recruits. Special exercises for recruits are frequently being introduced or old ones modified. One that was until recently much in vogue was that of increasing the difference between the maximum and minimum movements of the chest walls. The medical officer knows that this is not a reliable test of the real expansion of the lungs. A common error made by recruits is filling the upper and middle parts of their lungs at the partial expense of the lower. The collar bones and shoulders are raised as is also the upper part of the chest. There is a slight movement upward and outward of the chest, while the lower part of the lungs remains passive, the diaphragm being but little used. When breathing is correctly performed, in inspiration there is practially no movement of the collar bones and shoulders, but merely an upward and forward movement of the sternum or breast-plate, more especially its lower part, combined with elevation of the ribs and relaxation of the abdominal muscles, the reverse occurring in expiration. The diaphragm is the muscle which chiefly helps in expanding the lower part of the lungs, and the diaphragm is as amenable to development as any other muscle. Under a proper system of physical training of recruits the capacity of the lungs naturally increases without any special exercises such as abdominal breathing, etc. The only advantage of breathing exercises is to teach the recruit to breathe in such a way that he brings all the ordinary muscles of respiration into play properly. The increase of the lung capacity depends, of course, largely on the mobility of the chest-walls, hence within reasonable limits, the younger the recruit, the better results to be anticipated. The habit of breathing properly tends to the development of a roomy thorax, which is usually associated with a strong heart—two potent factors in marching and in resisting invasions of disease. The extent of real expansibility of the chest-walls, and of real expansion of lungs, is one of our tests of capacity for sudden and sustained effort.

Expansion of the chest and expansion of the lungs are not synonymous terms. The expanding lungs not only open out the air spaces, but also the blood spaces, which by drawing blood in, relieve the right heart. These spaces are not opened out unless the lungs are expanded in their more important diameter, the vertical, by means of the diaphragm ; and unless they are opened out, the respiratory movement does not assist the heart, which has to pump against increased resistance. When a man keeps his chest expanded with sinking in of the "pit of the stomach" and abdominal wall generally, the lungs are increased in the transverse diameter, and not at all, or very little, in the vertical diameter, and the venous spaces and capillaries are indifferently or not at all expanded ; only the superficial parts of the lungs are expanded, the deep parts are unaffected. Further, if a man maintains a rigid posture, the burden on the heart is still greater, because the burden of the circulation is greater

in a group of muscles in a state of rigid contraction than when contracting and relaxing.*

The practice of deep breathing exercises during gymnastic exercises is unnecessary, and probably of very little if any use. Men should from the beginning of their career as soldiers be taught to breathe through the nose. Mouth breathing keeps the mouth dry, and like tobacco-chewing, encourages thirst.

There can be no doubt that the physical training of former years was carried out too suddenly and was too severe, *e.g.*, the use of heavy dumbbells, pulling up the body with reverted hands on the horizontal bar, etc., threw immense strain on the heart.

The comparatively large number of men that used to be annually invalided for some form of heart trouble led to careful inquiries regarding the effects of the physical training of the soldier. It may be safely asserted that heart strain and its consequences is the one and only condition of ill-health that can be attributed to service in the Army. During the last ten years over 2,000 men have been invalided from our European troops for affections of the heart, or about 200 annually. The number of soldiers invalided for heart disease has hitherto been far in excess of those of other European armies. The average British recruit on enlistment is younger, less developed and of a poorer condition of physique than in other European armies.

The effects of the new system of physical training which was commenced in 1906 has already produced a beneficial change in our European troops ; the number of men invalided for heart affections has been much reduced. This system has not been in operation amongst our European troops long enough to test its merits beyond stating that the results show an improvement on the old. An epitome of the system of training of our European troops as laid down in *Manual of Physical Training*, 1908, has just been officially introduced into the Indian Army,† and one is fairly confident that this new method will have a far-reaching and beneficial effect on the development of our Indian recruits.

"The danger of trying to hurry physical training should be recognised by all. It is impossible to obtain good results by cramming more and harder work into the same or less time. If therefore a shorter time than usual is available for training, the work must not be hurried or increased, but should be regulated accordingly, and no attempt must be made to attain the same standard that can be reached in the longer period of time."

One has consulted several adjutants on the relative merits of the old and the new system of training, and they mostly were in favour of the

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* Lieut.-Col. E. H. DEANE, R.A.M.C., *Journal of the Royal Army Medical Corps*, October 1908.

† *Manual of Physical Training for the Indian Army*, 1911.

old system as bringing on recruits more rapidly and fitting them for duty in the ranks more speedily than the new system, although they admitted that it necessitated the ultimate rejection of a larger number of youths. On the old system one has seen many promising lads break down and become permanently unfit in consequence of the severity of the strain.

Necessity for thorough training.—The recruit is trained with a view to his being rendered capable of standing the strain and hardships of field service. The training of the fully developed soldier is maintained for the same purpose. This requires the soldier to be able to march long distances with his full equipment ; he has to possess good power of endurance, be in good health, and be able to stand vicissitudes of climate, exposure, changes of food, sometimes a scarcity of diet and unhealthy surroundings. On the thoroughness with which the individual recruit is trained and instructed depend his future usefulness as a soldier and capacity for marching.

When the recruit's course is finished, he is passed into the ranks and is considered to be a trained soldier, and he has yearly to go through further physical exercise to keep him fit for his duties.

" All physical exercises of the recruit and trained soldier should be carried out with due regard to elementary physiological facts and principles. It is not sufficient to develop and train certain external or groups of surface muscles alone and to neglect the heart, lungs and other internal organs, for it is on these internal parts, notably the heart and lungs, that the body as a whole depends, not only for its fitness, but for its very existence. Failure in the past to recognise this fundamental idea has been the cause of much undoubted harm to the young soldier."*

" In the special training of the *soldier* in order to fit him for his life as such, apart from the technical training of the branch of the service to which he belongs, the following requirements should be kept in view—*viz.* : a soldier should be well disciplined, a good marcher, intelligent, smart, active and quick, able to surmount obstacles in the field and capable of withstanding all the strains and hardships of active service. The required condition of physical fitness necessitates that the heart and lungs should, above all things, be sound and healthy ; but the harmonious development of the *whole*—the skeleton or framework, the internal organs (including the brain and nerves) and the muscular system—is necessary to produce this condition."†

From these considerations we see that the recruit requires some form of physical training before joining the ranks, the vast majority require special training, and from the early age at which they join the service it is reasonable to hope that all but a small fraction (less

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* Firth's *Military Hygiene*, p. 92.
† *Manual of Physical Training*, 1908.

than 1 per cent.) will go through this, and achieve the object aimed at; the method of training is definitely related to the requirements of the recruit and his subsequent duty of marching in the ranks.

A definite uniform system necessary.—Whilst there must be some definite and uniform system of training the physique of our soldiers, one which develops to the best possible degree the vast majority of them, we should not forget the personal equation in individual cases of men who cannot stand the strain of severe training, and who may yet make thoroughly efficient soldiers. We see this frequently in the varying sensitiveness of different horses in training to race. It will be borne in mind that the undeveloped lad cannot do the same work as a hardened and seasoned soldier—they do not yet possess the same powers of endurance, nor anything like the same resistance to disease causes. European and Indian soldiers of 20 years of age cannot be compared in capacity for marching with men of 25.

Premature fitness a mistake.—Men should never be passed prematurely into the ranks as trained soldiers merely to increase the strength of the unit. Such a blunder serves to tax those who are efficient.

The unseasoned soldier a burden in the field.—The ranks of unseasoned troops are apt to be rapidly depleted when called upon to march under the conditions of active service. Infantry fall out from sickness and sore feet. Advantage must therefore be taken of every opportunity to accustom troops to marching and thus bring the feet and muscle of men into condition, permitting of severe and prolonged exertion.

The soldier must be trained to be hardy.—Men must also be trained to be hardy. Without this quality, without the capacity to stand heat and cold, hunger and thirst, and fatigue, a soldier may be found wanting at the critical moment. A brave heart and firm resolutions fail when the flesh is incapable. Russian soldiers are taught to sleep out in the open air in the coldest weather; they do their route-marching often in snow storms. The rigid use of sterilised water will not keep a soft and defectively trained man from falling out on a hard day's march, or enable him to endure the fatigues, hardships, and exposure of a severe campaign. Hygiene in the field does little to help the man who is weak and wanting in endurance.

Out-door games and sports are invaluable auxiliaries to physical training; they are complementary to one another. All out-door games indulged in moderately and under appropriate conditions are healthy. They mean moving about in the open air, varied muscular exercise, and a healthy interest and excitement. Adults between the ages of 18 and 25 have all the joys of the athletic world open to them, and men who have kept themselves in training may continue to indulge in these privileges until they are 35. The middle-aged and elderly have to restrain their active pursuits, but they have still many outlets for energy in the form

of walking, cycling, cricket, etc. Methodical arrangement of physical exercises and out-door games develop manly vigour. We see this quality brought out in those who indulge in shooting, out-door sports, and out-door games generally. The football player has not only developed his muscles; he who has rowed in his college eight has done more than learn how to negotiate the sliding seat. The exemplary players of our manly out-door games have learnt more than the games at which they excel—they have been through a training in which they have acquired courage, pluck, self-reliance, endurance, quickness of eye and hand, and promptness in judgment; they understand what discipline and self-control are, they fully appreciate what we mean by good-fellowship and loyal comradeship; they will have learnt what it is to be patient, to be fair, to be unselfish, to be true, to be frank, straightforward and wholesome-minded.

Out-door games, however, can never take the place of physical training. "They have not the same corrective effect, many of them are one-sided, the same regular, systematic and progressive results cannot be obtained from them, and, apart from the difficulty of obtaining space for all to play, the greatest drawback to the use of games alone is that the weaker and less expert performer (*i.e.*, the very man who most requires training) is often discouraged by his want of proficiency and so ends in becoming a looker-on."

It was not until one visited practically all the great training schools for the youths of Japan—Tokyo, Osaka, Kioto, Kobe, Nagasaki, Hiroshima, Yokohama, etc.—that one quite understood how it is that the Japanese *simurai* is such a hardy warrior. In these schools one saw children of 7 or 8 years daily go through their lessons in the various forms of *jiu-jitsu*, sword exercise, physical drill, etc., and they continue to do so until the time they enlist, so that when the *simurai* is 15 or 16 years of age he is physically thoroughly trained and requires little but special training after entering the Army. The Japanese Army has included a modified Swedish system to complete the training of the recruit.

Any man who has received judicious physical training as a soldier can be readily distinguished from the untrained civilian. He has a springy step, an erect and easy carriage, his head is well raised, his chest is expanded and his shoulders squared.

MECHANISM OF MARCHING.

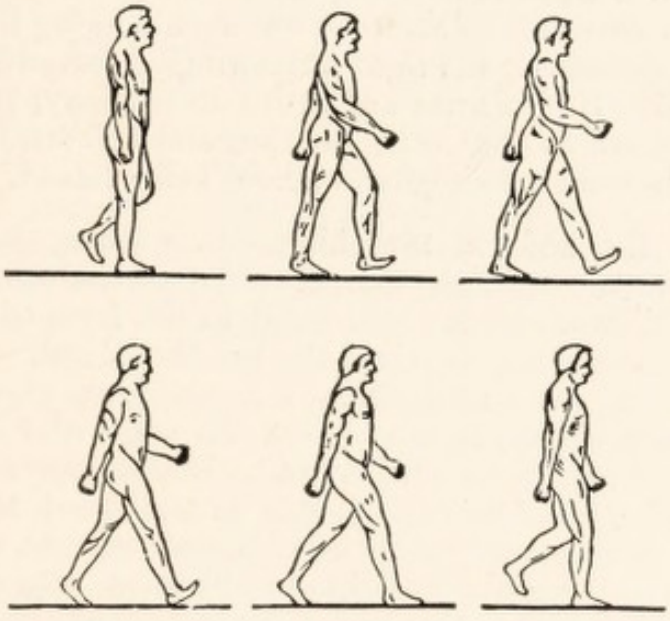
Definition of marching.—Military marching for our purpose here may be defined as walking with a particular covering for the body, carrying various articles of equipment which are arranged about the body in a special way, at a regular or fixed pace, the speed of which is adapted to the requirements of the average man of the ranks, but which must necessarily be unsuited to many.*

* Lieut.-Col. C. H. Melville, R.A.M.C., *The Physiology of the March.*

It is a truism to state that in a soldier marching in unity with a column, there is a certain amount of wasted energy. This is partly due to the restraint put on the physical freedom of movements of the limbs, and partly to the stiffness of the movement. No amount of special training can remove this fact. This training, however, is necessary, and eventually the well-trained soldier acquires a sort of mechanism which enables him to keep step, and his place in the ranks, with the minimum loss of energy.

In marching with the full field equipment the centre of gravity is being disturbed at every step, and this in a constrained way, as the lateral movements and freedom are limited ; under these circumstances there is a constant waste of energy. Hence the physical advantage of marching at ease and in open order, in which there is less energy lost and the demands on the muscular system are more deliberate.

Action of the feet in marching.—In marching the foot should only be raised from the ground as far as is required to clear any obstacles ; nor should it be advanced beyond where it is to fall. When the leg is at its greatest length, that is, when it has just urged the body forward and is lifted from the ground, it falls forward as a pendulum from its own weight, not from muscular action : and this advance is from within and



Military or straight-leg marching (after BRADFORD).

behind to without and before, which action alone carries the limb outwards.

The soldier should, however, be taught to restrict this outward inclination or eversion of the foot. A moderate inclination of about 10° best answers all requirements, as it favours the broadest basis of support with the maximum of claw-like propulsive movement from the toes.

"Under present methods of marching, the shoulders must be kept straight, the neck and body erect ; the knees are only slightly bent and the feet are thrown out well in advance of the body, the free arm swinging naturally (see lower diagram). In ordinary walking the heel touches the ground first, the greatest weight being borne by the flat of the foot, and the toe leaving the ground last (see upper diagram). Too often the soldier is taught or acquires the habit of placing the foot almost flat on the ground, thereby increasing the shock of impact and personal fatigue. The foot acts as a lever of the second order, in which the bases of the toes are the fulcrum, the muscles of the calf attached to and hauling on the heel are the power, and the resistance is the weight of the body transmitted by the shin bones to the ankle joints. In ordinary marching the toes should be directed well forward, so that the thrust backwards in the foot should be in the direction of its length and not across it."* In the official instructions it is laid down that "the legs should be swung forward alternately, freely and naturally from the hip-joints, each leg as it swings forward being bent sufficiently at the knee to enable the foot to clear the ground. The foot should be carried straight to the front, and without being drawn back, placed firmly upon the ground with the knee straight, but so as not to jerk the body. The body should be maintained as erect as possible, well balanced over the legs and carried evenly forward without swaying from side to side, and with head erect. The arms must not be stiffened but should swing freely and naturally from the shoulders ; the right arm swinging forward with the left leg and *vice versâ*. If the arms are swung in this way, they will bend naturally at the elbow as they swing forward and will straighten as they swing back, the movement being free without being forced."

Position of the body in marching.—In walking the whole body is projected forwards. In doing this the point of the centre of gravity of the body describes a circular movement in the form of an arc about the foot. The less the body is raised the less the labour. In long steps the arc, and the height to which the body is raised, are greater—in short steps, less. It is probable, however, that the angle at which the body is bent, and of course the co-efficient of resistance, are not materially affected by the length of the step, so long as the speed is not altered. The 30-inch step of ordinary time with 112 paces a minute, when the fully equipped man is carrying about 40lbs., is the most economical for his energies. It is probable also, that under the same conditions, the 33-inch step of "stepping-out" time is a trifle too long. The step should be shorter when carrying weights than when the body is unburdened.

The usual faults in marching are : (1) Body inclined too much forward from the hips ; (2) shoulders raised ; (3) body swayed from side to side ; (4) arms stiffened and shoulders brought forward ; (5) arms swung from the elbows only, with the upper arm kept still ; (6) arms

* Firth's *Military Hygiene*, p. 253.

swung across the body; and (7) knee bent as the foot is placed upon the ground.*

Heat formed in Marching and Effects of Marching.

Heat generated in muscles.—In marching certain groups of muscles are brought into action; as the result, progression is effected and heat is generated. These three factors of muscular action, movement and heat formation are intimately correlated. The muscles in acting contract, and whenever under any circumstances a voluntary muscle contracts, movement of some kind is produced, and heat is generated in the muscle. As previously stated, in the contraction of muscle there is oxidation of the combustible fluid elaborated from the food assimilated; all muscles are bathed in this fluid. This fluid contains readily oxidisable carbo-hydrate materials, the C and H of which unite with the O stored in the muscle, forming CO_2 and H_2O and producing movement and heat. The amount of heat produced is in direct proportion to the amount of muscular effort made; in marching we have a large number of powerful muscles acting and a large amount of heat generated, and this, after a time, raises the temperature of the body. "In a series of observations made in 1906 by Dr. Pembrey of Guy's Hospital and Capt. Parker, R.A.M.C., at Aldershot, soldiers marching under varying conditions of load carried, clothing and so on, the temperature of the men was taken on 359 occasions before and after marching. The temperature of these men was found to have risen on an average 2·3° F. above normal."† This rise of temperature is a normal incident in marching. "If the muscles are continually producing heat, one of two things must result: either the temperature of the body must rise to such an extent that further exertion would be impossible or the heat must be dissipated in some way or another. Ordinarily the latter is the case."‡ This rise of temperature in marching is physiological and inevitable, it is an inseparable concomitant of working muscles, and is essential and advantageous, and brings about compensatory physiological processes which remove the excess of heat. Under normal circumstances there is a corresponding increase of the amount of heat lost to the body by evaporation of the sweat from the skin, increased moisture from the breath, etc. The conversion of sweat into watery vapour uses up much heat.

The main factors which determine the amount of heat generated in marching are:—The *amount of moisture in the air*; the *form of equipment used*, including the nature of the clothes worn, the *weight of the load carried* and the *manner in which the load is distributed* over

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* *Manual of Physical Training for the Indian Army*, 1911.

† Lieut.-Col. C. H. Melville, R.A.M.C., *The Physiology of the March*, a lecture published in the *Journal of the Royal United Service Institution*, Dec. 1910, p. 1582.

‡ *Ib.*

the body ; and the *speed of the march.* Let us consider each of these factors in detail.

Effects of atmospheric humidity.—The heat generated in muscles from exercise is taken by the blood stream to the surface and got rid of in different ways, the chief of which are :—(1) Evaporation of perspiration (pp. 9, 10) ; (2) radiation and conduction from the skin (pp. 9, 10) ; and by the moisture of respiration (p. 7).

The effect of marching in the ranks on the amount of watery vapour thrown off from the body becomes very obvious on a cold morning before the sun rises if the atmospheric air is at all damp ; we then notice that a cloud of steam is emanating from the men as it does from horses after a hard gallop. The men of a battalion in all the companies except the first few in front are enveloped in this perspiration mist during a march, and those in the last two companies are marching through an atmosphere fairly saturated with moisture. This has a material effect in lessening the amount of heat given off by evaporation of perspiration and consequently tends to raise the temperature. Such a condition in an atmosphere that naturally has a high degree of relative humidity may distress the men very considerably. In a dry air the watery vapour evolved from the surface is not so easily seen, but it is nevertheless always present.

By far the most important means of getting rid of the excess of heat generated in marching is the evaporation of perspiration, and it is very important to each individual marching soldier that nothing should interfere with the heat lost in this way. In a dry air in which the moisture is taken up from the surface of the body with avidity, and in doing so lowers the surface temperature, the excess of heat resulting from muscular exertion is not felt. Should, however there be a high degree of relative humidity in the air, it will not take up the moisture freely from the skin, and then more or less distress is experienced in marching. Or, if the body is overburdened with clothes, the evaporation of perspiration is interfered with. In both cases heat accumulates in the body and the temperature rises—a form of "fever" is produced. In the presence of a hot tropical sun, under one or other of these circumstances, heat-stroke may occur. With proper clothing and an ordinary external atmosphere as regards humidity, the extra heat generated is dissipated by perspiration almost as fast as it is formed.

Form of equipment used and clothes worn.—The dissipation of heat from the surface of the body is also materially interfered with by the conditions under which the soldier must necessarily march. The civilian in walking can use clothing to suit his personal comfort, can burden himself with a load or not, can vary his pace, etc., and in all these ways lessen the amount of heat generated and the energy expended. In the case of the soldier, on the other hand, uniform clothing is necessary; he has to carry a load, march at a particular speed and length of pace in the ranks.

Removal of heat from the body is interfered with more or less by clothing, which in the case of the soldier is capable of only minor modifications to suit altered circumstances. This dissipation of heat is also affected by the mere fact of marching in the ranks, and may be seriously affected by meteorological conditions (pp. 11—13).

Every description of clothing impedes the loss of heat by evaporation of perspiration and radiation. "Even a slight difference in the amount of clothing worn makes a difference in the rise of temperature in the wearer. For instance, the same five men were marched from Cambridge Hospital to Pondtail Bridge and back on two occasions in drill order, the only difference being that in one case they wore their jackets and in the other they did not. In the latter case their temperature rose 1° Fahr., in the former 1½° Fahr. The effect on the body temperature of wearing a jacket on a warm day was about equivalent to carrying a load of 30 lbs. on a cold day."* From this it will be seen that the effect of allowing men to open their jackets is considerable and, curiously, it is seldom we see men open their coats spontaneously when marching. With the new infantry equipment this is easily done, and men should be encouraged to do it (see pp. 36, 37).

In marching, the amount of heat generated rises with every extra ounce carried and with each quarter of a mile extra speed per hour. This is well pronounced when marching up-hill, in which the total weight of the body is added to that of the load carried.

Weight of the load carried.—A battalion of infantry accustomed to carry a load of, say, 40 pounds, at the regulation speed of one mile in 18 minutes over 15 miles without any sign of strain in the men, if suddenly required to do the same distance at the same rate with a load of 50 or 60 pounds, no matter how well balanced the load, it would be found that a certain number of the men would have decided fever at the end of the march. This has been experimentally proved and may be accepted as incontrovertible. Further, a load of about 30 pounds in marching on a very hot day has much the same effect as regards raising the temperature of the body as one of 50 pounds on a cool day.

Manner in which the load is distributed over the body.—The position in which the load is carried by the soldier is exceedingly important. It is well known that a weight of say 30 pounds carried in the hand is much more fatiguing than a similar weight evenly distributed on the back and between the shoulder blades.

Weights are best borne when the following general principles are attended to :—

1. They must lie as near the centre of gravity as possible. In the upright position the centre of gravity is between the pelvis and the centre of the body, usually between the navel and pelvis, but varying, of course, with the position of the body ; a line prolonged to the ground

* Lt.-Col. C. H. Melville, R.A.M.C., *The Physiology of the March.*

passes through the astragalus in front of the os calcis.* Hence weights carried on the head or top of the shoulders, or which can be thrown towards the centre of the hip-bones, are carried most easily, being directly over the line of the centre of gravity. When a weight is carried away from this line, the centre of gravity is displaced, and, in proportion to the added weight, occupies a point more or less distant from the usual position until, perhaps, it is so far removed from this that a line prolonged downwards falls beyond the feet, the man then falls, unless by bending his body and bringing the added weight nearer the centre, he keeps the line well within the space which his feet cover. In the distribution of weights then, the first rule is to keep the weight near the centre; hence the old mode of carrying the soldier's great-coat on the back of the knapsack was a bad one, as it put on weight at the greatest possible distance from the centre of gravity.

2. The weights must in no case compress the lungs, or in any way interfere with the respiratory movements, or the elimination of carbonic acid gas from the lungs, or hamper the transmission of blood through the lungs, or render difficult the action of the heart. The old cross-belt and pouch combination was one of the worst conceivable arrangements in these respects.

3. No important vessels or nerves should be pressed upon. This is self-evident. An example of neglect of this rule was the old regulation knapsack, the straps of which so pressed on the nerves and veins in the armpits as to cause numbness of the hands, and often swelling of the hands and forearms.

4. The weights should be distributed as much as possible over the several parts of the body.

Those whose daily vocation is weight-carrying usually carry their weights either (1) on the top of the head—because the weight is then completely in a line with a centre of gravity and in movement is kept balanced; this method for obvious reasons cannot be used by the soldier; or (2) on the top of the shoulder-blades at their broadest point above—because at this point the weight is well over the centre of gravity, and it is also disposed over a large area of the ribs by the pressure of the shoulder-blades; or (3) on the hip-bones and sacrum—because the weight is near the centre of gravity, and is borne by the strong bony arch of the hips, the strongest part of the body. Besides the foregoing, use is made of the principle of balancing by those who have to carry great weights.

The question of equipment presents several points for consideration to the military medical officer, especially in regard to the distribution, adjustment and balance of the actual weight of equipment carried

* The *astragalus* and *os calcis* are two bones which form a bridge for the support of the two bones of the leg (tibia and fibula).

by the soldier, the effects of compression of the heart, lungs and arms due to belts and straps, and the general effects of the total weight carried on the man's physique and strength. The two former points need not be here considered as the weight actually carried now is fairly well distributed and the soldier marches with comparative comfort. Regarding the actual weight carried by the soldier on field service, there is a general agreement that it should be reduced to the smallest minimum compatible with the best fighting efficiency.

The load carried by the soldier requires to be arranged with the greatest care and thoughtfulness, so that the weights do not detract from the man's efficiency, or injure his health. The chief points to attend to are that the weights should be adjusted so that when carried they fall as near the centre of gravity as possible, and not outside it.

These principles are to a limited extent utilised in the bandolier equipment, and it is light and simple. The ammunition is contained in four pouches in the bandolier. The mess tin is carried either on top of the great-coat or under it when this is carried on the shoulders, or it is fastened to the waistbelt; in each case it can be detached without interfering with the rest of the equipment.

The most objectionable part of the bandolier equipment is the bandolier itself, which, when loaded with ammunition, presses on the man's chest.

The less evenly balanced and the more improperly disposed the load carried, the greater the exertion, the more the fatigue, and the greater the amount of heat generated. The nearer the weight to the centre of gravity, the less the balance is lost in marching, the less the exertion, and the less heat formed. Any load on the back displaces the centre of gravity more or less vertically or laterally, and the more it does so, the greater the tax on the work of the muscles to maintain the equilibrium. By practice, however, the muscles adapt their capacity to all reasonable requirements; without adequate training and practice even the strongest man is not fit to carry the full equipment under field service conditions on long marches. A newly-joined recruit cannot keep up with the completely trained man, chiefly because his heart, blood-vessels and lungs are not fully developed and specially trained. Some men are inclined to carry several articles which are really not necessary but which they find add to their comfort—all such additions increase the amount of energy expended in marching.

In calculating the work done in marching we should not forget that the man has his own weight to carry—the live weight—in addition to his clothes, accoutrements, knapsack, ammunition, rifle, etc.

There is a limit to the load which the trained man can carry without injury, and if this limit is exceeded, he soon runs down. What this limit is exactly in this country we do not know, but in Europe it is said to be about 50 pounds, or about one-third of the weight of a man's

body. The question of the weight of the load carried will always affect the facility with which a soldier gets through a march.

No part of the equipment should have any bands or straps going across the body above the waistbelt—all straps, webs, or bands should run vertically. It would be an improvement if the opened flaps of the jacket could be buttoned back. This opens up a large surface for evaporation of moisture and reduction of heat. "It would also be an advantage if the coat sleeves were capable of being rolled up or buttoned up so as to expose the skin of the forearms." All possible surfaces should be exposed for facilitating evaporation of perspiration in this way. Personally one looks upon this effect as the greatest point in favour of "shorts."

The new infantry equipment is simple in construction, light, durable, has no straps crossing the chest, and can be rapidly put on and off. It allows of the waistbelt being unfastened on the march, and even when taken off will remain completely assembled. It permits of a reasonable quantity of spare kit being carried on the march, and, if necessary, allows of the kit-carrying portion being discarded, leaving the wearer with his fighting essentials only. The main defect of this equipment is that it is very hot. Its weight alone is 4 lbs. 13 ozs., and,

New Infantry Equipment.
Front View.

New Infantry Equipment.
Rear View.

with a maximum ammunition capacity of 150 rounds, represents a total load, without spare kit and entrenching tools, of over 15 lbs.

The committee on the new infantry equipment drew the following conclusions from their experiments and observations :—

"The new equipment is superior to the old in the following respects:—The weight of the sack behind is so well balanced by the weight of the ammunition in front that marching can be performed with the belt, jacket and shirt widely open. There are no straps constricting the chest. The load is borne chiefly by the shoulders. The facility and quickness with which the new equipment, in full marching order, can be taken off and put on enable the soldier to obtain full benefit from any halt of a definite duration. The close application of the sack to the back of the soldier is a disadvantage which could be easily overcome."

The full equipment is comfortable, and the weight is not excessive for the man who has been progressively trained in marching with a load.

"The committee wish to lay stress on their former recommendation—'That it be an instruction to officers commanding that the order shall be given to men on the march in warm weather to open the jacket and shirt.' For they have evidence that it is not sufficient to leave the initiative to the company commanders or to the men themselves.'"

Whilst there is more ease in marching in the ranks now than in former years, we are unable to remove the physical constraint inseparable from large masses of men marching in column. All men are not equally fit, the indifferent marcher has to keep his place in the ranks with the good marcher. It is not possible to make the marching of fully accoutred and equipped soldiers as free and unencumbered as that of the individual walking indeperdently and unweighted, but our object should be to endeavour to approach this as far as practicable. What one would here emphasise is the necessity of permitting men to march without unnecessary limitations or restrictions—to move with as much freedom as the circumstances of marching in the ranks allow. At the end of the day's march the men should feel that they have had what is only a healthful amount of exercise.

When rain is expected, the great-coat should always be at hand. Men should, however, be discouraged from using their great-coats for every trifling shower of rain. While actually marching, rain will not, as a rule, do any harm. A great-coat weighing about 5 lbs., when saturated with rain, is very heavy. It is better to have dry great-coats to put on over sweaty, wet shirts and *khaki* coats when the march is finished, than to have the great-coat also saturated. During halts in rain, of course, the great-coat should be worn. The men should be cautioned against the prevalent practice of discarding their *khaki* coats as soon as they get into camp, and while waiting for

the transport to bring up their kits and tents. Their shirts are moist with perspiration, and they are then somewhat tired and prone to chill. On reaching camp the men should be broken off at once, take off their accoutrements, but not their coats.

Speed of the march.—The speed of marching also naturally affects the amount of energy used up and heat produced. If a load is carried on two occasions, say 1,000 yards in 10 minutes and 5 minutes respectively, the amount of energy expended is greater in the latter case, but there is this important difference, that in the 5 minutes instance there is one-half the time for the heat generated to be lost. The amount of fuel used by a railway engine in travelling rises with any increase of speed.

Each of us has a particular pace at which we walk with the greatest economy of energy, above or below which there is a waste of force. This is specially true of men marching in the ranks. All men have to accommodate their rate of progress to a definite pace both as regards speed and length of stride ; the weak man has to keep up with the strong, the man with a natural short stride with one having a long stride and those whose normal pace and stride are deviated from are using more energy than those in whom the rate of marching and length of pace are normal.

It is probable that with the full equipment, the most economical rate in an ordinary 12 to 15 miles' march is about 3 miles an hour including halts, but excluding the longer half way one. Small picked forces may go beyond this average for weeks, but large forces, even when consisting of chosen men, will rarely do so without strain. The pace laid down *F. S. R.*, Pt. I., p. 42, for an infantry column is one mile per 18 minutes (about 98 yards per minute), and infantry should be practised to keep this pace for long distances. In war time it will often be necessary to make men go at "step out" rate for many miles. Men cannot do this if they have not been trained to it in peace times. Rapid marching without time limits for distances during route marches should be practised during peace times. These should not be competitive with other units. "The length of the average march under normal conditions for a large column of all arms, engaged in extensive operations, is 15 miles a day, with a rest once a week ; small commands of seasoned troops can cover 25 miles a day under favourable conditions."*

The regular ordinary step is 30 inches with a cadence of 112 steps per minute ; a cadence beyond 120 steps per minute (that is the *quick march* pace) is undesirable, for what is gained in number is lost in length of pace ; the former of these two with full equipment is probably the most economical pace at which the march can be conducted. When loads are at all beyond the average weight, it is preferable

* *F. S. R.*, Pt. I, Ops. p. 43.

to have a shorter step than the regulation length. Our *double march* is, of course, a 40 inch pace with 180 paces to the minute.

The natural step, which varies with individuals, is usually about six-sevenths of the height of the limbs, which in average soldiers is 27″; this is too short a pace for ordinary marching. The ordinary step in the French infantry is 29½″ at 120 paces per minute and in the German 31″ at 112.

In practice the men usually choose their own length of step. It is much easier for the average man to increase the number of steps per minute than the length of the pace. The greater the load of equipment carried, the shorter should be the pace.

Estimation of mechanical work done by the body.—The expenditure of energy in marching over a flat surface varies with the speed of the pace. It is possible to calculate with a moderate degree of accuracy the amount of energy expended in marching at different speeds and carrying different loads. In estimating the work done by the body, we take into account the work done by the muscles of respiration and circulation as well as the more visible work of locomotion, etc.

Suppose we were estimating the amount of work done in marching. Here we have likewise to include the actual weight carried. The force exerted in breathing and in the action of the heart is equal to about 260 foot tons; this is the *internal work* of the body. Walking along a level road at the rate of 3 miles an hour is considered to be equal to climbing vertically $\frac{1}{20}$th of the distance travelled; if at the rate of 4 miles an hour it is equal to $\frac{1}{16}$th, 5 miles an hour, $\frac{1}{14}$th, and so on.

From this it is possible to calculate the amount of physical work done. Suppose a man weighing W pounds carries a load of W_1 pounds on a level road for D feet at the rate of 3 miles an hour, the energy exerted is equal to $\frac{(W+W_1)D.}{20\times2240\text{ (lbs. in a ton)}}$ = foot tons. If, for instance, a man weighing 150 pounds carries a load of 60 pounds on a level road for 20 miles at the rate of 3 miles an hour, the work done is equal to $\frac{(150+60)\times(5280\times20)}{20\times2240}$ = 500 foot tons. In marching at 4 miles an hour the denominator would be 16 and not 20. In ascending a perpendicular height a man, of course, carries his whole weight, in which case the 20 of the denominator would not be used. The energy expended in a fair day's work is about one-sixth mechanical labour to five-sixths heat produced in the body.

The tired man in marching is generating more heat and using up more of his store of energy than the fresh one. The same is the case with a limping man with a shoe-bite, a man with the load of his equipment badly disposed over his body as compared with one on whom it is evenly and properly distributed.

The march, of course, does not include all the energy expended by the soldier—there is the striking of the camp, loading up of the

baggage, the fall-in parade, the unloading and pitching of camp, incidental fatigues, guard duty, etc., to be carried out. It is most essential that the infantry soldier at the end of a march should still have left a certain storage of physical energy which could be liberated if occasion demands it.

"The severity of the march is not to be measured so much by its mere length in miles, but rather by other factors, such as pace or time in which it is done, load carried, and formation or position in the column."* The severity might often be gauged by estimating the time elapsing between the men moving about at *reveillé* to that of being comfortably located in their tents in the next camp. One would emphasise the necessity of not rousing men unnecessarily early, and especially of not making them linger about before marching off—this can easily be done by accurate timing when large columns are moving, and is always easy when a unit is marching alone.

Average length of march.—The ordinary march averages from 12 to 15 miles, but may vary from 8 to 18 or 20.

A march of 12 to 15 miles with full equipment may be considered a fair day's work for infantry. Much longer marches have been done in India; and in Europe during our own autumn manœuvres and those of continental armies, marches of over 30 miles have been done for six consecutive days, but this is exceptional.

A daily march of 20 miles with full equipment could not be kept up for any length of time without men losing stamina. In actual practice, however, if the troops are called upon to do rapid and long marches, they are done in light marching order kit with the equipment reduced to a minimum. The rapidity with which exercise is carried out is more important in calculating the physical energy expended than the actual amount of work done.

Other effects of marching are chiefly manifested on the circulatory and respiratory systems, and on the weight of the body. All these are due mainly to the one fact that marching brings about an increased oxidation or chemical change in the muscles with which increased heat formation is inseparable.

Effects of marching on the heart.—The number of beats per minute is increased—the beats increase in frequency as the temperature rises until the demand of the muscles for more O is satisfied, then it continues to beat at a uniform rate but much higher than normal. The heart must throw more blood into the muscles that are acting, thereby supplying additional combustible pabulum and more O.

The degree of atmospheric temperature likewise affects the rate o the heart beats in marching—the higher that temperature, the more

* Notter and Firth, *Theory and Practice of Hygiene*, 3rd Ed., p. 914.

frequent the beats. Indian troops generally and Gurkhas marching at the end of the month of March on the plains in the United Provinces have an average of 15 beats a minute beyond what they have when marching under the same conditions in the middle of January, and 8 beats a minute at the end of February, the body temperature remaining the same except in a small percentage of men ; but in March the men sweated almost twice as much, and in February about $1\frac{1}{2}$ times as much. These observations were made by me with the bandolier equipment. It would be interesting to ascertain if these statements hold good with the new infantry equipment.

Effects of marching on the respiration.—The increased utilisation of O in the muscles demands increased rapidity and depth of the respirations in marching (see pp. 17—20) to supply more O through the red blood cells in the circulation. The change in the respiratory rhythm is further necessary because of the enormous increase of CO_2 generated in the muscles and elsewhere as the result of the increased combustion processes. The lungs are the chief organs by which this CO_2 is eliminated from the blood (pp. 6, 7). CO_2 beyond a certain percentage in the blood is poisonous to both the respiratory and heart nerve centres.

The oxygen required for the chemical changes in the tissues and cells of the body is taken by the red blood cells ; in these cells it is held in a state of loose combination ready to be yielded up to the tissues and cells requiring it ; by the red blood cells O is carried throughout the body. The plasma or fluid which bathes all the cells of muscles takes a large share of this oxygen (p. 17). The more vigorously muscles are acting, the more energetic the chemical changes in them, the larger the amount of O used up in these chemical changes, and the more CO_2, water and other waste products formed. Partly to renew this supply of muscle-stored oxygen, but also for other reasons, the breathing is more rapid and the circulation of the blood more vigorous.

In walking in *mufti*, unencumbered by weights or equipment, we can and do unconsciously increase the depth and frequency of our respirations. The soldier in the ranks compressed by the equipment around his body, especially in the case of the bandolier equipment, can only increase the depth of his respirations to a limited extent, because of the compression of the chest ; with every inspiration his breathing muscles have, in addition to expanding his lungs with air, to raise the various weights disposed about his chest and abdomen. With the new infantry equipment these impediments to free breathing are reduced to a minimum and there is practically no interference with the heart's action. " In the bandolier equipment every expansion of the chest had to work against three straps, *viz.*, the bandolier containing 50 cartridges and weighing 4 pounds 9 ounces, the haversack strap

supporting a weight of 2 pounds 14 ounces, and the water-bottle strap supporting a weight of 3 pounds 12 ounces."*

Effects of marching on the weight of the body.—There is rapid and fairly considerable loss of body-weight in marching. This is chiefly due to the loss of water from perspiration. After an ordinary march of 12 to 14 miles on a hot day on a flat road with full equipment on, men lose several pounds, varying from 3 to 5 pounds or on an average 4 pounds in weight in this way, that is, roughly, about half a gallon of water. "The body of a man 10 stones in weight contains rather more than 88 pounds of water. Of this he can afford to lose a certain amount only. Any loss amounting to one-tenth of the total, that is, less than 9 pounds, unless replaced at once, means death, and long before that point is reached, naturally exhaustion will have set in."† This rapid loss of water from the body is one of the causes of syncope that we occasionally meet with in men marching in the ranks. If this loss is not replaced, the blood, which is now thicker and decreased in quantity, fails to supply the sweat-glands (p. 8) with the fluid required to secrete sweat; less sweat is formed, less heat is lost to the body which now becomes warmer, and this may go on to the extent of producing sunstroke. This brings us to the question of *water-discipline on the march*, but it is more convenient to discuss this under the heading of the *Hygiene of the March* (p. 63 *et seq.*)

Duration of day's march varies with strength and composition of column.—The length of time taken to do a day's march varies with the strength and composition of the force and the length of the column. When only a few regiments are marching together without any interruptions, a 15-mile march can be easily done in 5 hours or so. When 8,000 or 10,000 men are on the road together, the same march will take it 7 hours, often longer; a division will take 9 hours. Many circumstances delay marches: head winds—a strong wind acting on a large body of men will add from 10 to 20 per cent. in the time it takes to do a march; rain or snow add 10 to 15 per cent. Great heat, snow, dusty, sandy or muddy roads, darkness, steep hills, are all factors which prevent the normal rate of marching being maintained. Including halts an Infantry Brigade should average three miles an hour. It is unsafe to calculate on a large force marching on a road more than two miles an hour. The darker it is, the slower will be the pace.

March Discipline, Etc.

Leading unit to keep regular pace.—In marching in column the officer of the leading unit should remember that he is at an advantage and those behind at a disadvantage. It is very necessary that he should keep a regular pace; an irregular pace, with checks and rushes,

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* Lieut.-Col. C. H. Melville, R.A.M.C., *The Physiology of the March*, in the *Journal R. U. S. Inst.*, Dec. 1910, p. 1589.

† *Ibid.*

is very exhausting to marching men. "The rate of marching throughout a column should be uniform. The officer who sets the pace at the head of the column should bear in mind that an irregular pace tends to produce alternate checking and hurrying, and is most exhausting to the troops, especially to those in rear of the column."* "If distances are lost on the march, stepping out or doubling to regain them is forbidden except by order of the commander of the unit. Infantry will be ordered to quicken their pace only if a defile is to be passed rapidly, or some definite object is to be gained."†

Rapid marching may be required by the exigencies of war. In such a case the rests will be in proportion to previous training. Rapid marching should therefore be practised in peace.

Food before starting a march.—Men should never start a march on an empty stomach. In ordinary marches in India a large or heavy meal should not be given, but some light refreshment, such as tea or coffee and biscuits, or bread, for European troops, and tea and *chapatties* for Indian troops. The hot beverage and light food early in the morning rouses and sustains the men and cheers them up, lessens fatigue and increases the resistance to disease. The use of alcohol in any form during the march should be strictly forbidden. This rule should be absolute.

Best time to march.—The actual time of marching is governed by many considerations, such as the condition of the roads, state of the weather, and above all, by military considerations. Whenever possible, the march should be early in the morning, for at this time the air is cool, the men are fresh after the night's rest, and the early start enables them to get to the next halting-place before it is too warm.

The time for starting is scarcely a matter that can be fixed by any arbitrary rule, as it is to some extent determined by the circumstances just mentioned. The general rule, however, when the above circumstances do not weigh, is to start the march early in the morning. It is a matter of common experience that after the early morning march men show little signs, if any, real fatigue, whereas after a march that goes well into the day the reverse is the case, especially if the weather is hot.

Early morning marches in hot weather.—In the hot weather, the early morning hours are the best to march in all parts of India and its Frontiers. The plan now generally adopted in marching in peace time is to arrange the march so as to arrive in camp by 9 A.M., or a little earlier, when marching in the hot weather. When a long march is to be undertaken with the prospects of a hot day, the regulations advise that a halt of three or four hours should be made in the middle of the day. This allows men and animals to feed and rest, and is certainly a less fatiguing way of completing a long march under the circumstances.

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* *Field Service Regulations*, Part I, Operations, 1909, p. 43.
† *Ibid.*

During the winter months, a start before sunrise is best. If the march, however, is a long one, and likely to be associated with many interruptions, it is better to start in the dark in the morning than to arrive in camp after dark in the evening. In fixing the hour of starting the comfort of the troops should as far as tactical exigencies admit be considered. Men obtain most rest in the early hours, whilst it is always advisable that men should have their breakfasts. When practicable, therefore, the hour for starting should not usually be before daylight. The halting-place for the night should, if possible, be reached at least two hours before sunset. Tactical considerations, the length of the march or the state of the weather may, however, necessitate starting before daybreak.

Night marches.—Night marches are undertaken to avoid the heat of the day, to forestall the enemy, effect a tactical surprise, gain time either in advance or retreat, or to move troops to a position of assembly from which to deliver an attack. The roads should, where practicable, have been previously carefully reconnoitred. During halts at night men should be permitted to lie down.

Bad effects of night marching.—Night marches should never be undertaken except for strategical or other military reasons or for training. Night marching in India is now almost universally condemned as a practice even in the hottest weather. Refreshing sleep is most important to our men ; and in the hot weather, especially with an absence of shade, in dust, and possibly flies, men cannot sleep during the daytime. This is specially the case with our European soldiers, for they cannot sleep in tents during the day and soon knock up for want of rest. All experience shows that night marches eat into the soldier's staying power more than any other factor. Constant marching at night always leads to long lists in the morning state. Except under pressing military necessity night marches should not be continued as a routine in mobilising troops. Marches at night are seldom required. "Any attempt to march repeatedly at night invariably results in an increase of sickness, except under stress of military necessity the loss of sleep occasioned by such night marches may be considered as far outweighing the ordinary advantages to be gained thereby."

Open order on dusty roads.—On dusty roads and during hot weather the column may with advantage be opened out on each side of the road, the centre of the road being left clear. The dustier the road, the wider should be the open order. In very hot weather it may be necessary to open out a column by increasing the distance between sections of fours, and allowing an increased interval between men. This, of course, requires the order of the officer commanding the column.* One march formation should not be changed for another

* *F. S. R.*, Pt. I., Ops., 1909, p. 41.

unless the new formation can be maintained for a considerable distance. It is a sound rule to march in as open formation as practicable ; this facilitates ventilation in the ranks and greatly reduces the deleterious effects of cutaneous and respiratory exhalations. Marching in close order on dusty roads on a hot day is specially harassing to the men ; open formations avoid the effects of overcrowding. "Without ventilation in the ranks the air soon becomes very foul." When practicable, the various units of a long column should take it in turn to lead, as marching in the rear is more fatiguing and disagreeable. The same rule is applicable to the companies of units.

During the march breathing through the mouth should be avoided. This permits of the passage of particles of dust and germs into the lungs, and in the cold weather, of unwarmed air with possible irritation.

Condition of road, etc., as affecting marching.—The condition of the roads is always to be taken into account in estimating the fatigue, and wear and tear likely to occur in troops and transport animals. Fifteen miles on a good road is done by troops cheerfully and without any real fatigue ; a similar distance after a severe thaw on a broken road over an enemy's country, or even on a *katcha* road after heavy rain, would be extremely fatiguing to both men and animals.

If the ground over which a march is done is not level, is irregular, rough, sandy, rocky, muddy, or slippery, the expenditure of energy is greater as the load carried by the man in marching order on such surfaces tends to disturb the centre of gravity which has at each step to be re-established by extra muscular effort. If the road is rough, the foot is insecurely placed ; if sandy, it sinks ; if muddy or covered with frost, it slips ; if stony, it is liable to bruise—all these tend to increase the labour expended in marching. The best form of country to march in is one of low rolling downs since muscles are rested by variety of action as well as by absolute inaction.

Supply of water on the march.—"During the hot weather arrangements for supplying the troops with water during the short halts should be made." The men should start with their water-bottles full. In the enemy's country the medical officer should assure himself that the water has not been tampered with by the local inhabitants under instructions of the enemy.

Straggling.—Straggling in marching should always be strictly interdicted. Nothing is more depressing, demoralising and harassing to troops than straggling, and it must at all costs be prohibited. Its special remedies are to have none but fit men with the force, removal of all sick and incapable from the ranks at once, and in some cases assistance. We must, of course, be specially cautious not to encourage physical indolence for which the remedy is obvious. It is scarcely necessary to state here that straggling on the march is an evil that directly impairs the military efficiency of a command.

Mental occupation.—Mental occupation on the march tends to prevent fatigue and weariness. Absolute silence in the ranks is depressing. The men should be kept cheerful and in some way occupied. Regimental bands, drums and fifes, bagpipes, and bugles shorten the road, and the rhythm of the music affords an agreeable cadence to the step. Singing in the ranks, especially choral singing, should be encouraged. The Russians, I have been told, select beforehand certain soldiers to do the singing for their respective organisations during marches.

Two or more converging roads preferable for a large force.—Where there are two or more roads of advance when tactical considerations permit, the force should proceed by these and not adhere to one road. There are administrative advantages as regards food, quarters and comfort, inherent in dispersion as opposed to over-concentration which will nowadays be duly considered.

Halts on the march.—"Halts of 5 to 10 minutes are allowed after every 60 minutes' marching." The first halt might with advantage be made after the first half hour as this enables men to re-adjust any part of their equipment that is causing irritation, friction or discomfort. Regular halts are necessary to rest the muscles and relieve their tension—5 minutes after each hour's actual marching is amply sufficient for trained soldiers. When the march exceeds 12 miles it is desirable to rest for 15 or 20 minutes half way. There is greater economy of energy in this than in doing a 12-mile march in two stretches of 6 miles each with a comparatively long rest between them. Long halts are undesirable—they permit the muscles to stiffen and predispose to chills. The short halt, however, should be a real five minutes. One frequently sees two of the five minutes wasted in forming up at the side of the road, piling arms and breaking off. Lord Roberts' march to Kandahar proved the use of the short halt by what the force attained. In all unusually long marches, when possible, an advance party should proceed to the half-way halt to prepare tea or coffee—and lots of it—for the men. In this case what is required is liquid warmth, which, in the shape of tea or coffee, is an excellent restorative. Halts reduce the accelerated pulse rate, lessen the depth and frequency of the respirations, and permit the temperature, which has been temporarily raised, to return to normal.

Halts may often with advantage be regulated by the meteorological conditions—especially atmospheric temperature and humidity. If the air is cool and dry and the men in good condition, it is not always necessary to halt every hour, but if it is either hot or very moist, hourly halts are essential, and especially so if the air is both hot and moist. On the whole, however, a halt for five minutes every hour is the best rule to adopt.

During the halt with the new equipment the men should be encouraged to take it off—this rests all the chest and abdominal muscles, and allows the moisture to evaporate from the parts that were compressed

by the accoutrements and knapsack. Halts are most useful when the equipment can be removed to ease the men.

The intervals between the halts and their duration are often better determined by the nature of the country traversed than the actual length of the march. Except at the beginning of a march of some weeks' duration small bodies of troops do not require the same short intervals between the halts as lengthy columns do.

During halts men should be allowed to sit down or rest themselves in any position they find most comfortable, but they should never lie down on damp ground, especially if they are perspiring or overheated. Excessive scattering should not be permitted, each company keeping together.

The comfort of the troops *during the march* depends largely on the arrangements made by the staff. In the event of a long halt being contemplated during the march, a staff officer, accompanied by some mounted men, including mounted police, should always be sent in advance of the column by the officer commanding to make arrangements. He selects, in conjunction with a medical officer, halting-grounds for the troops and the first line transport, taking adequate measures to protect the water-supply till the main body arrives.*

Sanitation during halts.—The duties of the sanitary detachment of units are most important during the halt to prevent men rendering the neighbourhood foul and insanitary. It is urgently necessary that promiscuous fouling of the ground be prohibited. The moment the men are to halt, the officer commanding points out the place for the purpose, and the sanitary police should see that men using it cover up all excreta with earth. Each man should make a shallow excavation with the point or heel of his boot, bayonet, or a stick, into which the excreta should be deposited, finally replacing the removed earth over the excreta. If this is not done and a large force is marching in column, a terribly disgusting state may arise, and a vast amount of preventable disease be created. This practice should always be carried out on the line of march and on manœuvres. It is of extreme importance. An alternate method is that the sanitary detachment men should accompany battalions or other units on the march, in the proportion of one sanitary detachment man per two companies. This man is to carry a spade. Regimental standing orders should insist that :—(1) All men must cover their own excreta with loose earth, scraped up with a bayonet, sword or a boot ; (2) men except in very urgent cases must not be allowed to fall out between halts ; (3) at short halts, say, for under half an hour, the sanitary detachment man should report to the senior company officer of the two companies to which he is attached, who will indicate to him a suitable place to which men falling out must go. The sanitary detachment man must at once proceed to the spot accompanied by the men wishing

* *F. S R*, Pt. I, Ops., p. 47.

to fall out. He will either himself cover up their urine and fæces with earth, or see that the men do so in some way. No men should be allowed to rejoin their companies or column until this material is covered; (4) when halts are for longer periods than half an hour, or when outposts are placed, the sanitary detachment man must proceed as directed above to the spot intended to be used for excrement, and there dig a few short shallow trenches for defæcation and one shallow trench 3 inches deep as a urinal.* With Indian troops one sweeper per double company should, under the supervision of a sanitary detachment man, be employed in covering up all excreta with earth.

These orders should be rigidly enforced and the British officer of the day should visit the places, see that they have been left in a clean state and report the fact (or otherwise) to the officer commanding. Men not carrying out these orders should be duly punished. One feels sure that if men and officers thoroughly understood the dangers of the old custom of promiscuous defæcation and urination at every halting-place without any precautions, the matter would receive the attention it deserves, and the men would fully co-operate in carrying out all orders on the subject.

Necessity for a weekly halt.—When marches are to be continuous, a halt of once a week is necessary to keep the men fit.

Delays on the march.—It is necessary to avoid tiring delays in starting; the careful regulation of the march is necessary and each arm of the column must be required to time its arrival at the designated point at a definite moment. Once started, the march has to be continued steadily, regularly, and without hesitation. Such minor obstacles as pools of water, mud on the road, etc., must be surmounted, for delay in the leading unit is transmitted along the whole column. It is much better when obstacles and other causes of delay occur for the leading units to march slower. Irregular progress is always very vexatious to marching troops. The time lost in waits of indefinite duration probably cost more in nervous strain, and actual fatigue to troops than the same time spent in marching, since the uncertainty of the delay maintains the men in a condition of constant uneasiness, prevents the temporary removal of the equipment, and destroys much of the benefit which might otherwise result from such halts. Hence whenever such halts can be foreseen, they should be announced at the beginning, and the whole column be notified accordingly. Even accidental halts should, when it is practicable to measure their probable duration, be made use of to rest the men in the same way as during ordinary halts.

Conserve the energies of the troops.—It is the duty of every commander, from the highest to the lowest, to spare the troops under him all fatigue that can be avoided. He will do all in his power to prevent

* Col. R. H. FIRTH, R.A.M.C., *Military Hygiene*, pp. 260, 261.

unnecessary expenditure of physical strength which invariably means loss of power. Men must get as much rest as possible. If an early start is contemplated, no man should stir till ordered to turn out. Preliminary arrangements for breakfast should be seen to overnight.*

"However well troops may be trained in the art of marching, they cannot be expected to continue efficient in this respect unless they are spared every demand on their powers of endurance not absolutely necessitated by the object for which the march is made."† Troops already tired do not march very successfully. Hence heavy field exercises should not precede a march.

Meaning of over-fatigue.—Both on the march and on field service, but specially in the latter, over-fatigue should be avoided. It is only under critical circumstances that men should be required to make every possible physical effort to achieve a particular object. It occasionally does happen that such an effort must imperatively be made, but this is usually when the men are themselves more than eager to accomplish it. By over-fatigue we mean a condition in which the vital, physiological, and physical processes have temporarily been subjected to some strain, they have been called upon to use up their reserve of energy, and require rest for their restoration—there is, in general terms, a temporary exhaustion of natural forces. In this condition men are very prone to chill, because the normal state of the circulatory system, which protects against chills, cannot be called into play; the system is then very susceptible to the ravages of disease germs, because the natural resistance of the various cells which act as barriers to such germs is much lessened, if not quite suspended; all the physiological processes—heart's action, respiration, digestion, etc., are conducted sluggishly. Hence eating a full meal in this state is liable to be followed by acute indigestion, colic, diarrhœa, etc., because the cells of the stomach and small bowel which secrete the digestive juices are for the time being unequal to their normal task.

Recently it has been advanced as a scientific fact that the quickened pulse and respiration that occurs in fatigue are due to the effects of definite toxins produced by the muscles during exertion. In response to these toxins fatigue antitoxins are created. Without knowing it, the athlete, when beginning to train, commences with gentle exercise during which small quantities of antibodies are developed against the toxins created; he is thus unconsciously inoculating himself with toxins and counteracting their effects with antitoxins. He slowly increases his dose of fatigue and at the same time greatly increases his capacity to make fatigue antibodies, and so after a week's training he is able to neutralise doses of fatigue toxins that would in the untrained cause great prostration. I do not know that these statements have been proved; they certainly give a reasonable explanation of a common experience.

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* *F. S. R.*, Pt. I, Ops., 1909, p. 59.
† *F. S. R.*, German Army, 1900 Ed., para. 306.

Necessity for sleep.—The most perfect rest the soldier on field service can get is a sufficiency of sound sleep. During sleep less blood goes to the brain and the functions of life or vital action are carried on uninterruptedly. Sleep comes naturally to the tired body and mind; it is not necessary to search after it. By sleep we ought to be completely refreshed, and on waking in the morning feel equal to, and eager for, the day's work before us.

Selection of season of year for marches.—As far as practicable, the best time of the year will naturally be chosen for long marches; but military exigencies do not always permit of this, and in a long campaign, such as the third Burma War (1885—87), almost every variety of weather and marching may have to be endured. One can recall occasions in Burma in 1887 when in May and June, we had to make various short detours, usually lasting 14 to 16 hours, when the temperature in the *pounghi kyoungs* we occupied was 110°—112°F. In Thibet there was the other extreme of many degrees below zero, plus the effects of rarefied air at heights varying from 12,000 to 16,000 feet. In a short expedition up the Khanki Valley to the Lozakka Pass to recover rifles and fines, early in December 1897 (before Karuppa was evacuated), we had 14 degrees of frost for the two consecutive nights, in which we bivouacked. We have still fresh in our memories the march of the 35th Sikhs to the relief of Malakand from Nowshera in 1897 with its dreadful roll of cases of heat apoplexy.

The state of the weather should always be taken into consideration, and where extremes of climatic influences are to be expected, precautions should be taken by the administration accordingly in regard to the clothing to be worn, any accessory articles of kit needed, and modifications of the field service scale of food required.

It is perhaps on some occasions worth while considering whether in marching in India, when there is no pressure of time, it is not well to ease off the speed of the march for the last few miles or so before reaching the next camp so as not to bring the men into camp in too heated a condition; this specially applies to marching when the weather is warm, and when there is likely to be a long wait before the men's tents and kits arrive.

When marching is to be continued for weeks, long marches at the outset, in the absence of any pressing urgency, should be avoided, whenever practicable. The distances may be gradually increased until at the end of a week a full march may be accomplished with ease by all men.

The general effect of marching when properly regulated is undoubtedly beneficial to the health of the soldier. He either gains in weight or remains more or less stationary, has a good healthy colour, and a very good appetite. If from any cause marching is injuring a man, he usually loses weight, the muscles become soft and flabby, and he becomes apathetic and haggard.

Good marching depends largely on the efforts of regimental officers to give full effect to all the regulations as to training for marching and march discipline. Under the head of march discipline is included everything that effects the efficiency of the soldier during a march, *e.g.*, the fitting of boots, arrangements for food, the constant inspection of men's feet and boots, etc.

All followers and non-combatants should be allotted a definite position on the line of march and must not be allowed to leave it.* Followers are prone to wander into adjacent villages and in them purchase all kinds of unwholesome food, drink unauthorised water, and possibly acquire some infectious disease.

Forced Marches.

A forced march is any distance from 24 to 30 miles, and occasionally even 40 miles, done in 24 hours. Forced marching cannot without inordinate strain be carried on beyond 36 hours without a period of rest. It is scarcely necessary to state that for forced marches only the fittest men should be selected. From their nature they are often carried out under conditions involving some hardship, scarcity of food and little sleep; they are associated with much fatigue and soon eliminate the less physically vigorous and imperfectly trained. The main object of the march is to maintain men in a state of physical vigour and fighting efficiency under the conditions of field service. Continued forced marching cannot be gone through without some loss of condition, hence they are only occasionally practised in peace times. At the end of a forced march troops are unusually fatigued, and require unusual rest and recuperation before being fit for further extended exertion.

"A forced march depends rather on the number of hours during which the troops are marching without halts than on the pace of marching. If troops are called upon to make a special effort, they should be made to understand that it is for a specific purpose. Forced marching should be resorted to only when the expenditure of fighting power thereby entailed is justified by the object to be gained."†

Every effort should be made to decrease the load carried by the men in forced marches. This may mean that the man has to do without certain articles of equipment and expose him to vicissitudes of weather for a short time, but in thoroughly trained men such exposure does no harm. In forced marches the supply of an adequate quantity of wholesome drinking-water is of paramount importance. When called upon to do forced marches for any unusual length of time, it is necessary that the men should get a certain extra quantity of good wholesome digestible and palatable food.

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* *F. S. R.*, Pt. I, Ops., p. 49.
† *F. S. R.*, Pt. I, Ops., 1909, p. 43.

Doubling and Running Exercises.

Doubling and running drills are necessary for the soldier from many points of view, especially in that they are indispensable exercises. They should be commenced for short distances, and gradually increased in pace and duration. They should, however, not be practised too frequently, especially with the full equipment, and they should be limited to an outside duration of 10 or 12 minutes. It is well at the beginning to do without arms and accoutrements, after a time gradually increasing the load, the men carrying first arms, then accoutrements, ammunition, canteen, water-bottle and haversack, and finally their knapsack. When they are in good training, in each exercise the pace at first should be fairly slow, gradually increased to the maximum speed required, and finally gradually decreased. They should run mainly on the ball of the toe striking the ground lightly—running on the flat of the foot is fatiguing, and on rough ground may lead to sprained ankles and other injuries. During running the lungs get rid of nearly fourteen times as much CO_2 as in the sitting posture—this fact alone indicates the activity of the waste and change going on in the body during the more active exercises. Running as an exercise and recreation is useful in many outdoor games.

Men with indications of heart weakness should not be allowed to run, and men should be allowed to fall out if they feel any strain, especially recruits, for a strain of this kind may damage them permanently. It is especially necessary to watch for the early signs of heart and lung embarrassment and for indications of exhaustion.

In these doubling and running practices the acme of the training is reached when the men can do their 1,000 yards without being too blown to use the bayonet at the end of it if necessary. Men who have been on the plains all the summer at comparatively light duty are, as a rule, unfit to do this 1,000 yards at once when the training season begins; they should, as in the initial training, be gradually brought to it.

In concluding this part of the subject I feel that it is only right to state that the effects of the march, the most economical pace of the march and how it is best carried out, are physiological problems that have not been completely worked out yet, and it is possible to conceive that a generation hence military medical authorities may be giving expression to views contrasting materially with those I have attempted to expound. The opinions I have given here represent, I believe, those of the best military medical and physiological authorities of the present day.

CHIEF DISEASES AND CAUSES OF INEFFICIENCY ON THE MARCH.

The chief causes leading to men falling out are—diarrhœa, colic, sore feet, faintness, and, in the hot weather, heat syncope and heart

strain. Dissipation and drink at night cause diarrhœa, and eating unwholesome or badly cooked or stale or decomposing food, causes colic and diarrhœa.

The main diseases to be on guard against in camps on the march are—*typhoid fever*, which arises from contaminated water and milk, soil infection, fly infection and infection through "carriers"; *dysentery* and *diarrhœa* from specifically contaminated water and soil, food infection from flies, etc.; it is also greatly predisposed to by defective food and imperfect cooking, and abdominal chills; attacks of *malarial fever* from chill in men already infected with malarial parasites; attacks of *bronchial catarrh*, *bronchitis*, and *pneumonia*, all specially predisposed to by chill, remaining in wet and sweaty clothes, especially in a wind; *heat-syncope* from the effects of the actinic rays of the sun; ordinary attacks of *fainting* from temporary overstrain. There is always the possibility of *cholera* occurring from specifically contaminated water, milk or food in districts where this disease is prevalent; and of *plague* from infection in districts where it is either endemic or epidemic.

Heart strain.—This is specially met with in young and incompletely trained troops, especially during warm weather and unusually long marches. The man usually complains of pain in the chest, breathlessness, giddiness and inability to carry his equipment, and there may be palpitation of the heart. The pulse is weak and there is the general appearance of exhaustion. Restricted respiratory function is an important cause of heart strain; this is fostered by any mechanical compression of the chest wall, by tight-fitting clothes, belts and weights crossing or pressing upon the chest and abdomen. The indications are, therefore, to loosen the clothing, remove the equipment and convey the man to an ambulance. It is wrong in principle to attempt to make such a man continue the march—this may damage him permanently. Men with weak hearts from any cause seldom make good marches, and if treatment, rest, and subsequently judicious training does not remedy their condition, they should be invalided.

Care of the feet.—Proper care of the feet is incumbent on every soldier and must be insisted on by his officers and non-commissioned officers. In something like 25 per cent. of infantry soldiers the feet are damaged in one way or another during the first week's march. Even with every possible care and precaution a certain number of men suffer and are temporarily rendered inefficient from this cause. The chief causes of footsoreness are ill-fitting boots, holey or badly darned or dirty socks, and dirty feet.

The feet of all troops on the march should be washed every day, and when water for the purpose is not available, they should be thoroughly wiped with a wet towel or cloth, special care being taken to wipe the toes and between them—this removes dirt, grease and sweat. A lather

of soap with hot water on the feet before putting on the sock, or even rubbing the inner surface of the sock with soap, saves many cases of footsoreness. There are numerous other simple plans of preventing sore feet with which all military medical officers are familiar, and which they apply to individual cases. Men who are inclined to have sweaty feet might use an ointment of 2 per cent. of salicylic acid in vaseline, or use daily a ½ per cent. solution of formaldehyde. The following powder is also useful :—Salicylic acid 3 parts, powdered Venetian talc 87 parts, starch 10 parts. These applications are, however, not preventive. The proper remedy is good fitting boots and good socks, and insisting on the men cleaning the feet daily. The proper care of the feet must to a large extent be left to the soldier himself.

One of the first cares of the medical officers on the march will be the state of the men's feet. For the first few days it is advisable to hold a daily foot inspection, and place under treatment any bad cases of blister or shoe-bites. He will at the same time see the men's boots and socks, advise regarding any defects he notices in these, and insist on the men washing their feet with soap and water at least once a day. The seasoned British soldier seldom omits to wash his feet at the end of a march and put on dry clean socks. Washing the feet once a day when on the march should be made compulsory. It is no unusual thing, in an infantry battalion, to have to treat an average of 10 to 15 cases daily of shoe-bites, inflamed corns or bunions, ingrown toe nails, etc., during the first six or eight days' march. Taken early, the great majority of these are readily set right ; neglected and poisoned by septic germs they may necessitate the man's being sent back to the depôt. A simple shoe-bite or blister in a thoroughly clean man is a very temporary inconvenience, whilst in a man whose feet are layered with dirt and micro-organisms it may mean weeks of inefficiency. Footsoreness from defective socks is always avoidable. Socks should be without holes, and when darned, the material used should not abrade the skin. If the men have two pairs of boots each, both pairs should have been taken into wear, and shaped to the feet, before commencing the march. The inefficiency caused by sore feet can be greatly reduced by the systematic attention to the matters dealt with here by company and section commanders.

It has been stated that our Army suffers more from efficiency due to sore feet than any European Army. One is unable to say how far this is true, but it is certain that the regulations regarding the care of the feet and state of the boots are more explicit, and the discipline on these points more stringent, in the German and French armies, than in our own.

Regarding the hygiene of the feet, it is unnecessary to state that the medical recruiting officer, when passing recruits, should be specially careful that no man with defective feet is posted to the infantry. Men with badly formed feet can seldom be good marchers and should not be

recruited for the infantry. Recruits should from the outset be taught how to look after their feet, and with this object they might on enlistment be provided with a printed card of instructions as to how this is to be done.

Chiropodists—one per company.—It is worth considering whether we should have a system of regimental chiropodists—men who have been instructed as to the best method of preventing all the smaller affections of the soldiers' feet and how to treat them. The addition of a chiropodist to each company would greatly facilitate this.

The company chiropodist's duties should be defined, and every week during peace times he should inspect the men's feet, their boots, and socks, note any tendency to corns, blisters, surface soreness, ingrown toe-nails, etc. The causes of the special conditions should be explained to the men, together with the way to prevent them. When proceeding on the march men might be given one of the numerous preparations for hardening the feet, and those who are known to have any special tendency to blistering, ingrown toe-nails, corns, etc., should, when on the march or on manœuvres, see the chiropodist daily until the tendency disappears. Under such circumstances men can have no excuse for falling out from "sore feet."

In the Indian Army double company or squadron barbers are moderately skilful in dealing with corns and cutting toe-nails, and a few lessons by the regimental medical officer would considerably enhance the value of the barber's work.

Dr. Klefberg (of the German Army) says: "A hospital orderly specially trained in diseases of the feet should be permanently appointed for this exclusive duty with each company; surprise inspections should be made frequently, when both the feet and boots should be carefully examined, and any neglect treated as a military crime; only regulation boots and socks should be allowed to be worn; and these are to be made on natural models. To effect a quick distribution of easy fitting boots on mobilisation, each man's small book should note the length, width, and circumference of such boots; these measurements should be legibly marked on the side of the boots in store for mobilisation purposes. Patients suffering from inflammation of the toe joints, or from periostitis (inflammation of the covering of the bones) should be put to bed; a soldier who by reason of this condition of his feet is unfit for infantry should, instead of being permanently invalided, be posted to some other branch of the service." The recruit should have feet in every way free from defect and deformity, and if properly looked after, they should improve and be better fitted for marching year by year.

Stock of boric acid powder in quartermaster's stores.—It is desirable that every quartermaster should have in store (or in the

canteen) a supply of powdered boracic acid to dust between the toes and over any part that is rubbed.

The full inspection of all boots and socks is urgently called for before a march. All socks with holes, or rough darnings, or worn threadbare should be condemned and replaced. The causes which should lead to condemnation and replacement of boots are sufficiently obvious and call for no remarks.

Boots.—It is impossible to emphasise too much the intimate relationship between well-fitting and well-made boots and the soldiers' military efficiency. A pair of boots that prevents a soldier from marching is directly answerable for the man's inefficiency, but the real responsibility is in the original issue of the boots. It is on record that 30,000 German soldiers were unfit for duty during the first few weeks of the Franco-German War on account of injuries of the feet, due to badly fitting boots that had become hardened by long keeping in the supplying stores.

Footsoreness may arise from initial defects in the structure of the boots, or from boots being allowed to get hard, or to their being worn out and it being impossible to repair them. The nature and shape of the boots and the quality of the leather are important. A boot should be considered as natural when its greatest length is in a line through the middle of the heel and middle of the great toe, and its greatest breadth through the bases of the five toes (metatarsal bones), this latter giving an oblique line in relation to the axis of the foot. The heel should be strong, resistant, broad, not more than one inch in height, and long enough to support the whole heel of the foot. It has often been a question whether laced ankle boots or long boots are best—the former are cheaper, easier to put on, and easier to dry, whilst long boots protect better against damps, cold and injuries. The question, however, does not arise in our infantry soldiers in India, who have all the advantages of laced boots and *putties*.

"Rubbing" of thighs.—Chafing of the inside of the thighs from rubbing of the trousers when wearing "shorts" without proper under-drawers and from dust and sweat, may be a cause of much discomfort. A drying powder of oxide of zinc and boric acid (1 to 3) or simple boric powder, the use of suitable drawers, and the practice of real cleanliness, are usually sufficient to relieve this.

Diarrhœa on the march.—On our N.-W. Frontier, especially when diarrhœa prevails, the falling out of men to relieve nature is always associated with risk. It is well to advise men to relieve themselves before the march begins, during a halt, or when the march ends. The medical officer will, of course, avoid the use of purgatives as far as possible, and when given, they will usually be of a simple nature.

Advice against chills.—The medical officer should at the beginning of a march forbid men taking off their upper garments because they

feel hot and are sweating. The risk from chill after great exertion, when the physical resistance is below par, is a real one, operating in various ways for evil. In hot weather the heat developed by physical exertion must be thrown off by the lungs and skin; if not, heat accumulates within the system, and heat-stroke or sun-stroke may result. The soldier in marching in the hot weather with a full kit usually sweats considerably, loses water from the body, but the formation of heat under muscular action goes on. If the air is already humid, evaporation from the surface is interrupted. Again, if there be a scanty water-supply on the march, and he cannot replace the fluid lost, sunstroke may arise. A full supply of water should be always ready at hand.

Heat Apoplexy.

Synonyms.—Sunstroke—Heat-stroke—Sun Traumatism—Insolation.

This is an acute condition arising from a sudden disturbance of the heat regulating centres of the nervous system by exposure to high atmospheric temperature, particularly when in combination with marked humidity, occurring in persons specially predisposed to the effects of the sun or in those unaccustomd to it, aned characterised by fever with very high temperature, and usually with convulsions and coma, and congestion of internal organs, especially of the lungs and brain.

The human economy is capable in withstanding comparatively high atmospheric temperatures for a short time, but this adaptation often fails when the air is fairly well saturated with moisture. In this latter case the heat regulating apparatus of the body is disturbed and loss of heat by evaporation is prevented by the large amount of moisture already in the air; as a result the temperature of the body rises. We have considerable power of adapting ourselves to, and keeping in good health under, the most diverse conditions of climate and temperature. Persons in health and vigour, leading temperate and hygienic lives, can endure much higher tropical temperatures than those who are less fit, and, as we know, Indians can stand a higher temperature ordinarily than Europeans, yet even the former may find the sun heat beyond their powers of endurance under certain exceptional circumstances. In true sunstroke the high atmospheric temperature produces excessive activity of the heat-producing mechanism by paralysing those parts of the heat regulating centres which control the heat discharge (vasomotor nerves and sweat glands).

True sunstroke is fostered by fatigue, tight-fitting clothes or compression about the chest and neck, thirst, debilitating diseases, constipation of the bowels, want of a proper amount of sleep, and excess of all kinds, especially alcohol. Europeans recently arrived in the country are more liable to it. Certain persons are especially susceptible for some unknown reason. Previous illness greatly predisposes to sunstroke. Stations in which hot winds are prevalent have invariably

a certain number of cases of sunstroke each year. The most dominating predisposing cause is alcoholism; even when only moderately indulged in it increases the tendency to sunstroke. In chronic alcoholics heat apoplexy is very dangerous as it is also in men worn out by fatigue and long marches.

When sunstroke has occurred, the equipment should be removed, the clothes loosened, and the man carried to any shade available. His head, neck, face, chest and spine should be bathed with cold water, and he should be vigorously fanned. If he can swallow he should be given small quantities of water at short intervals, and he should be allowed to rest quietly until the arrival of the medical officer and ambulance transport.

Prevention of heat apoplexy.—When possible, marching and work should be done in the morning and evening. Before going out in the morning a light breakfast should be taken. All unnecessary exposure to the direct rays of the sun should be avoided, as should also all lying about or sitting in the sun. In tents, free ventilation should be arranged for, to keep the air circulating and help evaporation from the surface of the body. If there are any signs of being affected by the heat of the sun, or the atmospheric temperature, it is a useful precaution to douche the whole head and back of the neck with cold water.

Rate of marching in sun.—It is well known that in hot weather the more rapid troops march beyond, say, 3 miles an hour, the greater the number of cases of heat-stroke occur; similarly, the ratio of cases increases with the length of the march, and this apart from the question of the actual number of hours they are exposed to the sun's influence. In actual fighting the mental strain and unconscious muscular rigidity which accompany military movements favour the occurrence of sunstroke.

Clothing.—The clothing worn should be suitable and our present *khaki* coats worn, over a flannel shirt, with "shorts," can scarcely be improved upon, but the new infantry equipment is much superior to the bandolier equipment.

Head and spine covering.—In our European officers and troops the head, temples, and back of the neck and spine must be well protected, and a special non-conductor in the shape of a detachable spine and back pad of quilted cotton wool is of great service in protecting a vulnerable part of the nervous system from the sun, especially when the latter beats on the back. Many experienced sportsmen use this when shooting in the hot weather in India. A handkerchief between the helmet and the head is also some protection, and green leaves of any kind if available still better. It has been suggested that the actinic rays may be an important factor in the production of heat-stroke and that these should be arrested by a layer of coloured material acting as a filter; orange or red, is such a colour; under-garments and a hat-linnig of one of these colours is recommended by some authorities. The helmet should always be worn between sunrise and sunset.

Coats should be opened.—On the march the men should be ordered to open the buttons of their coats.

Best form of beverage.—For a hard day's work in a hot sun, probably one of the best beverages is cold tea without milk or sugar.

Alcohol to be strictly interdicted.—The old notion that alcohol was a prophylactic against malarial infection, cholera, chills and disease generally, has been exploded. The use of alcohol in any form previous to beginning or during a march is to be absolutely prohibited. "Alcoholic drinks, gluttony, excess of animal food, too much tobacco smoking, in fact dissipation of all sorts, are specially to be deprecated."

Camps should, when practicable, be pitched in airy places, preferably on grass and under spreading trees, on areas free from undergrowth. Double canvas and grass on boughs laid on the tents will lessen the temperature within. In this connection in standing camps, a thatch erected over the tents adds much to the men's comfort and this is usually practicable.

Reflected rays of sun.—It is stated by some authorities that some of the symptoms of sunstroke are caused by the reflected rays of the sun through the eyes, the optic nerves being exposed to the direct rays of sunlight. Without discussing the validity of this assertion, we know from experience that neutral-tinted glasses decidedly afford much relief and comfort to the wearers in a bright hot sun. Such glasses in the form of goggles were effective in our Egyptian campaign in 1882 as a protection against glare, heat, sand and flies.

Perspiration not to be checked.—Anything which interferes with loss of body heat predisposes to sunstroke such as too heavy clothing, diminished perspiration from deficient water-supply, or lessening of evaporation from the surface from excessive humidity of the air. One has seen as many as five European sailors under treatment in the European General Hospital in Calcutta on the same day in the month of May when the shade temperature was well under 100°, but the humidity of the air between 70 and 80° of saturation.

March in open order.—Men should march in as open order as possible to allow free access of fresh air to each soldier. Halts should be frequent and whenever possible in shaded elevated places. During the halts the men should not lie down on the bare ground except under the shade of trees, as the ground is often hotter than the air and the men's bodies.

Unnecessary fatigues to be stopped.—Violent exercise, constipation, and deficiency or want of sleep are to be avoided. All unnecessary fatigues, piquets, and other trying duties should be avoided as much as possible; this applies especially to the middle of the day. All drills should be reduced to a minimum.

Company officers to watch their men on the march.—When marching in unusual heat, company officers should watch their men carefully. When a soldier looks pale, weak and exhausted, he should be told to fall out and rest, and be brought in by the ambulance transport.

Water-bottles to be filled.—The water-bottles should be filled at the halts. Arrangements for having water carried should be ensured before the march. This is most important. There should always be an organised system for the conveyance of sterilised water on the march and of having it in the field during an action. Water should always be easily accessible to the men.

Daily supply of ice if obtainable.—When cases of heat-stroke are expected, if ice is procurable in the district or province, arrangements should be made for an adequate supply of it to reach the camp daily.

Heat Syncope.

Synonym :—Heat Exhaustion.

Nature of.—In sun syncope or heat exhaustion the patient becomes pale and giddy and falls to the ground ; there is partial unconsciousness ; the condition is one of syncope or faint ; the pulse is weak and small, the breathing which may be stertorous, is usually shallow, the pupils are dilated and the skin is cold and covered with a clammy sweat. The patient usually recovers rapidly, but occasionally the shock is so severe as to lead to rapid heart failure and death. There is often a severe headache following this condition and in some cases an irregular fever. Occasionally inflammation of the membranes of the brain may follow it, or other form of brain trouble. Heat exhaustion is specially liable to occur when excessive humidity is associated with high atmospheric temperature, but this latter factor is not essential, as it often happens in Northern India where the air is particularly dry.

When the actinic rays of the sun act on a susceptible person, it produces a condition resembling either aggravated fainting or syncope or a form of shock. It is common amongst troops marching in the sun or people working in the sun, especially when in association with scanty food and hardship generally. It is considered to be a form of cerebral shock caused by exposure of the head and spine to the ultra-violet rays of the sun's spectrum. It is associated with an acute congestion of the brain and spinal cord which is usually only very temporary, but may in some cases be followed by chronic inflammation of the membranes covering these organs. It is specially liable to affect young Europeans coming to this country. The condition is one to which acclimatisation is possible. Indians are, however, liable to it and one has treated 11 men in one Indian infantry regiment of 700 strength for it on the march in the North-Western Frontier in September, and 9 men in another Indian Infantry detachment of 175 on the march in Upper Burma in May. The slighter forms of it are

constantly met with in Indian troops during manœuvres and on the march.

Other minor effects of the actinic rays of a hot sun after prolonged exposure are—severe sunburn, often with the formation of blisters, severe headache and fever. This condition is rapidly recovered from and is due to the action of the special rays named. Heat syncope often picks out those who are in a poor state of health or have recently been ill, especially when the illness gave rise to any form of degenerative change in the heart muscles which permits of the heart undergoing rapid dilatation under the strain of a high atmospheric temperature. This in all probability is the explanation of the manner in which chronic alcoholism operates in predisposing to heat syncope as in such cases there is almost invariably some degree of fatty degeneration of the heart.

Treatment.—In mild cases move the patient to the shade, open the clothes, place him in a recumbent posture, splash cold water on the face and neck, and apply smelling salts to the nostrils. If he can swallow, give him a drachm of sal volatile in a wineglassful of water. In severe cases apply a mustard plaster to the chest and nape of the neck, and if the temperature threatens to run up, wrap the patient in cold wet sheets and give cold water to drink.

Prevention.—The preventive measures are practically the same as for heat apoplexy.

Medical Inspection before the March.

Every officer, non-commissioned officer, man and follower must, by regulation, be subjected to a medical examination as to his fitness for field service, before being allowed to proceed to the front. The same applies to all long marches and to manœuvres.

What fitness for marching means.—Fitness in this respect signifies that during times of peace the physical and intellectual processes are being constantly enriched, the state of health is being maintained at the highest possible standard in all men, the powers of endurance progressively enhanced, the stamina improved, the capacity to resist disease-causes rendered greater, and the actual fighting power of the individual brought to its highest pitch of perfection.

It is necessary that all cases of disability from whatever cause should be left behind as they will only serve to encumber the hospitals. Only really fit men, sound in wind and limb, are to be allowed to proceed with their battalions.

Medical examination of units.—For this inspection the men should parade without coats, with their neck and chests bare, their shirt sleeves rolled up to the elbows. The medical officer passes down the front and rear of one company at a time, dismisses it when finished, and passes on to the next company.

In carrying out this medical inspection of a battalion the medical history sheets, arranged in companies, troops, or batteries, should be at hand, so that in all doubtful cases the medical officer may be able to refer to them at once. This inspection should not be hurried. A note-book should be used, and all men about whose fitness the medical officer is doubtful should be fallen out and grouped together, for more detailed examination subsequently.

Chief conditions calling for rejection.—Amongst the diseases and conditions to which the inspecting medical officer should direct special attention are—presence or absence of fever, the hand being applied to the exposed chest of all men ; indications of malarial infection—anæmia, enlarged spleen ; syphilitic rashes ; skin eruptions generally ; the presence of emaciation ; the condition of the eyes, which is significant to the medical officer in many maladies ; and the state of the gums, mouth, and teeth should receive particular attention.

Malarial infection.—Regarding malarial infection, the medical officer knows that every man who has suffered from recent malarial infection is an abiding source of danger to his comrades in the presence of malaria-bearing anophelines.

Exclusion of venereal cases.—No man with any existing manifestations of venereal disease should accompany a marching battalion, and with all European, and most Indian troops, especially unmarried Gurkhas and Punjabis, a venereal inspection is necessary. Opportunities for acquiring such disease on the march are limited, but not absent. Where their acquisition is possible, the preventive measures are essentially disciplinary, and rest with commanding officers who should "place out of bounds" all localities in which venereal disease may be acquired. Amongst European troops in particular a rigid venereal inspection is an imperative necessity.

Marching battalions are practically always much healthier than those quartered in cantonments, which is to some extent explained by the fact that in marching they change their environment daily, for it is well recognised that aggregations of men permanently located in a place tend to bring about more or less contamination of the soil and of their immediate surroundings.

In marching on manœuvres, or to take part in a campaign, and in the early part of the campaign, there will usually be a weeding out of seedy men, of those with latent disease which becomes pronounced under the strain of service, and of those of poor physique, these latter being usually in the younger men.

PART II.—HYGIENE OF THE MARCH.

Duties of Medical Officer, Etc.

On the march the medical officer inspects the men as frequently as possible, not formally or to worry them. He should avail himself of every reasonable opportunity of being amongst the men, and take mental notes of their condition. He should give orders that all cases of indisposition are to report sick at once. Men very seldom sham sickness on the march or when going on field service, and certainly never at the front. I have never known a man on field service to report sick without adequate cause. *Apropos* of this, one remembers the case of a man of an Indian infantry regiment in No. 14 Native Field Hospital in Mandalay in 1887, who had been wounded in the upper part of the right thigh several months previously, and constantly complained of severe pain in the region of the wound, long after it had healed. He was then a prisoner under observation for shamming sickness. A new medical officer on investigating his case, suggested that an operation was necessary. This was performed and a nerve tumour (what we call a *traumatic neuroma*) was excised from the external cutaneous nerve at the upper and outer part of the right thigh. From the moment of the operation the man did not complain of his neuralgia.

The medical officer sees that the rations are properly cooked, that the kitchens are clean, and the cooking utensils are cleaned and if necessary tinned ; that the men do not expose themselves to chill or the sun unnecessarily ; that they bathe themselves and wash their clothes when opportunities offer. When bathing in deep waters, a bathing piquet with ropes should be on duty while men are bathing. One has seen five cases of drowning with troops on the march. We have several times seen crocodiles in Indian rivers and canals near where men of regiments were bathing. British troops should be warned about the dangers of the sun on the head when swimming. Not more than ten minutes' swimming should be permitted.

On halt days, the medical officer should see that the tents are opened out, the kits aired and sunned, that tent drains are dug, that the camp area is properly cleaned, and the latrines in as satisfactory a condition as possible.

Peace duties of medical officers are a training for war.—In a general sense, so far as individual regiments are concerned, the preventive

measures on the march on field service should be no abrupt departure from those adopted in peace times on the march and during manœuvres. On the march the medical officer with the unit at each camp inspects the water-supply, which is almost invariably from wells, rivers or streams, where necessary permanganates it or orders it to be boiled, filtered or otherwise sterilised ; has a sentry placed on the source of supply to prevent its pollution, and others over sources (if any) unfit for use ; he forbids the watering of animals, bathing and washing of clothes where drinking-water is drawn from ; allots places for bathing and washing of clothes, watering animals, etc. ; he inspects the food-supplies of all kinds to be issued to the troops, including the milk, and interdicts the sale and use of whatever he considers unwholesome ; select sites for the night-soil trenches or latrines and night-soil incinerators, and for the deposit and incineration of all camp refuse ; sites for the kitchens, and for transport animals ; ascertains whether there is any infectious or prevailing disease in neighbouring towns or villages, and if so, has these placed "out of bounds," and sentries posted at safe distances to prevent the troops visiting these infected places. After the first week or so only occasional foot inspections should be necessary, and at these he also continues to note the state of the men's boots and socks, endeavours to rectify any personal causes of disease or general insanitary practices he observes, and assures himself that the camping ground is left in a clean state, and fit to be re-occupied at once by another regiment. As camping grounds in India are, as a rule, already fixed, he seldom has to select a site, but this is sometimes necessary, as on manœuvres, or when the prescribed sanitary camp for occupation during epidemic disease has to be suddenly evacuated, or when epidemic disease occurs in the immediate neighbourhood of regular camping-grounds on the march. In this case he applies his hygienic knowledge to the question of the most suitable available site.

Sanitary and other arrangements of camp to be made known to men daily.—After a march and before the troops are dismissed, water and fuel picquets are to be detailed when necessary. The places of water-supply for drinking and cooking, bathing and washing of clothes, watering of animals, the bazar, position of kitchens, latrines, refuse pits, and boundaries of unit's area and of the district, are to be made known to the men.

Temporary latrine-trenches may be necessary.—Pending the construction of the necessary latrines, urinals, and refuse pits, temporary trenches must be at once prepared to prevent soil pollution. The construction of such latrines is, whenever possible, to be avoided ; the latrine trenches should, wherever practicable, be ready for use when the unit arrives in camp.

Sanitation of units to be thorough and regular.—It is most essential that the sanitation of camps of units be carried out thoroughly

each day, especially when brigades and divisions are passing along the same route to manœuvres or to the front in succession. Otherwise the camping grounds may become centres for the spread of disease in the troops from the beginning of the march. The special points demanding attention are the prevention of pollution of all water-supplies, scavenging of the surface of camps and their immediate surroundings, the burning of all refuse, and strict attention to the condition of the night-soil incinerators or trenches. The encampment of the transport corps and transport animals generally, whether they be mules, camels, bullocks, donkeys or elephants, needs special watching, as they are often most objectionable.

Cleaning of camp site before quitting.—The rule that obtains on the march in India should be rigidly observed on field service. All camp sites should be thoroughly cleaned up under the supervision of a British officer after the regiment quits it. This cleaning is necessary as the camp will be required for other troops advancing and possibly also on the return march.

Sanitary responsibilities of commanding officers.—All commanding officers of units should be fully acquainted with the responsibilities in connection with the sanitation of their regiments. This is to a certain extent now laid down in Regulations. The commanding officer should define the limits of the regimental camp for the sanitation of which each of his officers is responsible.

Position of supply and other depots.—When marching or camping in brigades or divisions, officers commanding units are to be informed of any localities or depots outside his own area on which he may draw for water, fuel, straw and other supplies. In each district a place for a market will, if necessary, be selected, and a tariff of prices arranged. All persons coming into the district to sell articles of any kind must be confined to this place.

It is for the medical officer or sanitary officer to make minute inquiries of the local village or town authorities as to whether there is any form of infectious disease in the village, town, or neighbourhood of the proposed camp, and advise as to precautionary measures necessary.

Personally one has invariably drawn up a brief set of sanitary rules to be observed by all ranks on the line of march, these being published in regimental orders for general observance. On all such occasions one has invariably obtained all possible assistance from commanding officers in carrying out hygienic measures calculated to maintain the health of their men.

Water-supply on the March and in Camp.

Importance of the quality of drinking-water.—The quality of the water drunk by the soldier on the march, on manœuvres and in the

field, is one of the chief determining factors in regard to the state of his health.

Boiling is the safest method of sterilising water, and when combined with reliable filtration is also the best method. Where boiling has to be carried out on manœuvres or on the march, the water party should go on the day before to carry out the process and have the cooled water ready for use from the regulation containers by the time the force arrives.

Boiled water should be stored in clean vessels, and excluded from all possible sources of contamination.

Where the quality of the water is doubtful and on account of want of time we cannot supervise its purification personally, it is safer to use tea or coffee—the boiling of the water in making these kills all germs.

There are many forms of heat sterilising apparatus, all those in use at the present day being based on the principle of sterilising water by means of heat exchange. The heat of the water that has been sterilised in the pipes is utilised to raise the temperature of the incoming cold water as it goes to the sterilising chamber, whilst the cold, which the water parts with, is utilised for reducing the temperature of the sterilised water. In this way the sterilised water may be discharged from the apparatus at only 10°F. warmer than it enters it. There is much probability that some special apparatus devised on the principle of heat exchange will in the future form the means of supply of a large part of our Army in the field with sterilised water. The water for European troops may be boiled in the ordinary *camp kettles* and placed in the zinc cylinders, metal *pakhals* or canvas containers.

After weighing all the conditions associated with our Indian Frontier Warfare, one has come to the conclusion that boiling is the most practicable way of sterilising the water-supply for troops. One recognises this as a bold recommendation, and knowing how difficult of introduction it is, in our Indian Army at least, it might be considered to be impracticable. This is not so, and one feels that until some more reliable means is discovered, the difficulties connected with fuel, extra labour, supervision, and detail of working in boiling water for *all* troops in our Army in India on field service, must be overcome somehow. Boiling and filtering apparatus can, of course, be easily used in standing camps.

The water-supply of European troops must always be under responsible European supervision, and whenever possible this should be the case also with regard to Indian troops until native officers, non-commissioned officers and men are made thoroughly familiar with the dangers attending the use of contaminated water. It is of importance to have no possible alternative water-supply for European or Indian troops, for in that case the one not authorised will sometimes be used with disastrous consequences.

No sanitary regulations can make provisions against all accidents, but apart from very exceptional contingencies it should be possible to guard against all water-borne disease in soldiers by due regard to the water-supply.

Cleaning of water-bottles.—Special attention should be given to the cleanliness of men's water-bottles. This is an important duty. It is useless to put sterilised water into germ-laden, unclean bottles. Water-bottles should be scalded and rinsed out twice a week. This need only take a few minutes, should be done at a definite fixed time, and water for the purpose provided, on field service, on manœuvres, and on the march, the refuse water being discharged into an absorption pit. In the absence of boiling-water the water-bottle might be washed in a solution of permanganate of potassium if this is available. Very hot tea kept in the water-bottle for an hour or so is also a partial steriliser. Tea that has first been infused put into water-bottles and allowed to cool is quite safe. Cold tea sterilises a water-bottle as far as typhoid bacilli are concerned in 24 hours. In the absence of any of these means, the water-bottle may be rinsed out three or four times with clean cold water under supervision and as a matter of routine duty. Water-bottles should not be scoured out with sand and pebbles, as these themselves often contain disease-germs which may directly infect the bottle. Water should not be kept in water-bottles when they are not in use. The men's water-bottles should always be filled with authorised water before beginning the march, or with tea or coffee without sugar or milk.

Water discipline should be insisted on with all recruits. Properly disciplined men with empty water-bottles will not, under ordinary circumstances, drink the nearest water available until they know that it is wholesome.

Use of unauthorised water to be strictly interdicted.—While referring to water here, one would repeat that all soldiers, both in peace and on field service, should be strictly forbidden to drink unauthorised water. This rule must be rigidly enforced under all circumstances, in garrison and in the field. In our future campaigns all water not directly from reliable springs will probably be sterilised in some way. On field service only such sterilised water should be consumed. Whenever authorised water is available, the water-bottle should be filled. This boiled or sterilised water must, however, be kept sterile. Sterilised water in dirty water-bottles soon breeds germs. One has repeatedly, in examining water-bottles, found the angles and joints in a germ-laden state.

Soldier to be trained to control his thirst.—Soldiers should be methodically trained to keep under control the desire to imbibe large quantities of water or other liquids when they feel thirsty; they should be disciplined to this during manœuvres, on field days and on the march.

Such restriction is very necessary, and particularly so in the young soldier, in whom the habit of deluging himself with liquid is easily acquired, but it is in him also easy to prevent before such a habit is developed. Where soldiers are thus trained, they resist the yearning to drink the first water they come across on field service. The drinking of large quantities of fluid is mainly habit. To yield to the inclination to completely assuage thirst grows—it can be kept in check. Ability to control thirst is one of the tests of endurance. Frequently, simply rinsing out the mouth and back of the throat with water will remove the desire to drink. One cannot condemn with sufficient emphasis the attitude that officers used to adopt a few years back, to the effect that it is useless to attempt to stop men drinking water anywhere and anyhow, under the conditions of the march. One knows from experience with many regiments that this can be done. The soldier, if he is taught how to take care of his health, will do so, and he will certainly drink wholesome water when it is provided in sufficient quantity in preference to water of uncertain quality.

Excessive drinking adversely affects a man's marching powers, and makes it difficult for him to dispense with a plentiful supply of water. Men should not be permitted to fall out for water ; when necessary, halts will be made to enable men to fill their water-bottles. It is difficult to interfere with thirsty men using their water-bottles, but we should take every opportunity of explaining to them the inadvisability of deluging themselves with liquid unnecessarily, and that drinking to excess is largely a matter of habit.

The arbitrary control over the use of the water-bottle on the march is, however, unwise and impracticable. Undue restriction of the use of water during marching associated with profuse perspiration may be dangerous. Lieut.-Col. C. H. Melville, R.A.M.C., puts the matter forcibly : " There are two kinds of thirst, the thirst of habit and the thirst of necessity. The former is the habit any man can be trained out of. It is very different with the thirst of necessity which is the cry of the thickened blood for water. This is the thirst you cannot train men out of, or at least only to a small extent with exceptional men. It is a thirst which we cannot without risk interfere with. Hence there must always be water available for marching men. The quicker or more forced the march the more water is required." If the thirst of habit is eliminated by training, then men know when the thirst of necessity is assailing them and there is every reason why they should gratify it.

Ice for sick and sunstroke cases.—Before quitting the question of water, one might incidentally remark that when the force is within a reasonable distance of the line of railway in hot weather, the necessity of getting up a supply of ice for the sick and for possible cases of sunstroke should not be forgotten.

Food on the March.

The method of feeding the Army is a very important factor as regards efficiency, and we should be familiar with the main points which should regulate the selection of certain foods, their method of preparation, digestion, their uses in the economy, and the various diseases that might arise from defective feeding.

Importance of proper food on the March.—The food of the soldier is one of the most important concerns of a march and its importance grows with the length of a march. Defects in the diet as a rule take some time to develop their evil consequences. The bad results of a diet deficient in quantity, defective in quality, lacking in variety, unbalanced as to the *proximate principles** required for the normal physiological working of the economy, improper preparation or defective cooking, etc., sooner or later manifest themselves. In one or more of these ways the factor of diet may affect marching capacity. Accidental errors in diet, or at times the eating of certain articles of food, may, on the march as in cantonments, produce their effects abruptly in the form of acute indigestion, colic, diarrhœa, acute food poisoning, etc., but this is an exceptional occurrence and need not be here taken into account.

When possible, the same care should be taken in the cooking and preparation of food on the march as in cantonments. It should always be wholesome and appetising—tasteless food, lacking in variety, leads to a loss of appetite with its inevitable results. The soldier should be taught to cook his own food and to make it palatable from the materials he will have at his disposal on field service.

For British troops collapsible *doolies* with fly-proof wire-gauze panels all round might be used to store and protect all food from dust and flies. A liberal supply of wire-gauze dish covers should be in every officer's mess. All food-safes and wire-gauze covers should be thoroughly scrubbed with soap and water frequently. All utensils used for holding food, or cooking it, should be thoroughly clean, and well scalded and cleaned after being used at each meal.

Too much attention cannot be given to the food of the soldier in the field, especially as to the quality and quantity of its staple articles and as to its variety ; a liberal allowance of vegetables, particularly fresh potatoes and onions, should be provided, as well as fresh meat to European troops and some branches of the Indian Army ; and the food should invariably be properly cooked. The culinary processes in camps on the march are usually more rough and ready than is necessary.

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* The different substances entering into the composition of any article of food are conveniently referred to as *proximate principles*, "because consisting as they do of carbon, hydrogen, oxygen and nitrogen, combined more or less with highly complex bodies, they are really elementary constituents or proximate principles of the human organism." (Notter and Firth : *Theory and Practice of Hygiene*, 3rd. Ed., p. 221.)

Hot food at end of a March.—All experienced officers recognise it to be very desirable that men should have some hot food at the end of the march. Waiting for baggage to arrive and meals to be cooked whilst the body is soaked with perspiration and in a state of physical depression is very liable to lead to chill, attacks of fever, bowel complaints, etc. For European troops a pint of hot strong soup, cocoa, or tea and a biscuit on arrival in camp or bivouac after a march, is very refreshing and cheering, and then the men can wait for the next meal without impatience ; the feeling of fatigue, lassitude, and depression after a long march rapidly pass off, and give place to contentment and a readiness to take things as they arise. For Indian troops a similar quantity of tea is also an excellent restorative.

Many ways have been proposed to supply hot food at the end of a march to the men, such as providing travelling carts with boiling water, with which and tea, or soup tablets, the man can make his own tea or soup in a few minutes, every man carrying his own tea and soup tablets and a few biscuits, etc. ; or with a self-cooking apparatus like the "Calorogeneration." So far none of them can be considered perfect.

Exercise before and after meals.—As soon as food is eaten, the digestive tract is at once supplied with an extra quantity of blood, partly at the expense of the other organs of the body. We should not therefore undertake any hard exercise immediately before or after meals. It is advisable to give the stomach at least a short rest at these periods. Active exercise immediately after a meal disturbs digestion. But persons in health may do anything that does not require severe exertion. When the active part of digestion is over, we feel once more invigorated and fit for work, whatever it be. Never eat a full meal when in a state of bodily fatigue, as in this condition the digestive process is slow (see p. 49).

The food should be so prepared as to be eaten with enjoyment and relish. Hence the necessity of understanding, anyhow, the first principles of cookery. It is also desirable that officers should be acquainted with the details of the culinary processes carried out in the soldiers' kitchen, and interest himself in these by occasional visits to the kitchen while the preparation of the food is in progress. The work carried out in the kitchen has an important bearing on efficiency. Monotony in diet, defective and unsavoury preparation of food, insufficient cooking, and other defects are often associated with increase of sickness rate, and a general loss of stamina of the men.

The nature of the food materials sold to men by hawkers and others in camps requires constant watchfulness, especially in such things as sausages, meat pies, *kababs*, fish (fried, dried, salted), ice creams, milk, confectionery of all kinds and fruit.

Responsibility of medical officers regarding food of the soldier.—The medical officer with his special training, should be an expert in connection with all questions relating to the soldier's food in peace and

war. On field service especially, the medical officers of units, principal or senior medical officers of divisions or brigades respectively, and sanitary officers of divisions have their personal responsibilities in the matter of the soldier's diet ; and the points alluded to, and others not included here, should receive their attention. One knows from experience that whenever any avoidable defects are pointed out to officers commanding regiments, supply officers, etc., such defects are, when possible, rectified immediately. These officers want such advice, and they look to responsible medical officers for it.

Cooking of food—its importance.—The cooking of the food should be specially attended to, particularly when men are working under high pressure. The medical officer attached to units should insist on this and all officers in the regiment should co-operate with him in the matter. With Indian troops, he should emphasise the necessity of properly boiling the rice and *dal* which he should frequently examine between his fingers in the cooked state, see that they are soft, and that the *chappatties* are properly baked, and not eaten in a doughy or half-raw condition. In the case of European troops he should inspect the bread, the cooked meat, and vegetables, and see that no part of the latter escape proper preparation. Wheaten flour must be used for bread. *Atta* is undesirable either as bread or *chappatties* for European troops, who are unaccustomed to it and under its use soon suffer from diarrhœa, indigestion and general lowering of the system. Complaints are frequently made about the bread, and in most cases one has found these justifiable. It is rare to find any defect in the wheaten flour itself—the fault is usually in the kneading, the yeast (or other agent used for "raising"), or in the baking.

When men come in from a long march, and have but few hours to sleep before they are required again, they are disposed to give little attention to the preparation of their food, which under this circumstance is sometimes eaten half-cooked. This, apart from robbing the food of some of its nutritive value, tends to lay the foundation of various intestinal maladies—this is the very serious factor which prepares the mucous membranes of the bowels for the multiplication of the enteric bacillus, of the different species of the dysentery bacillus, and of the infective diarrhœa met with in long campaigns on our Indian Frontiers, and in campaigns in the East generally. The cells covering the healthy mucous membrane of the alimentary tract are powerful antagonists to the attacks of disease-germs, but when those cells are themselves weakened by constant irritation from improper food or defective cooking, and their resisting powers are reduced to a minimum, then such germs, which are probably more or less constantly present, get the upper hand and commence their work of invading the mucous membrane and deeper parts, or help other disease-germs which have gained access to do so. This is with special reference to dysentery and diarrhœa—the analogy holds good with regard to other diseases, such as enteric fever.

Coffee shops.—Coffee shops with European troops on the march may be a convenience, comfort and very useful in many ways if thoroughly organised and regularly supervised by regimental officers ; but in the usual way they are run they may be a serious source of disease, under which circumstance they are to be condemned as field institutions. If thoroughly supervised by responsible officers, they are a great acquisition ; otherwise they should not be permitted to exist.

Hawkers of food.—Hawkers of food, milk, confectionery, aerated beverages, etc., should be strictly prohibited from accompanying troops on the march.

Alcohol on the March.

The problem as to the use of alcohol in the Army in peace and war is such an important one that it may be interesting here to consider some of the salient points which will enable us to form some definite opinion as to the limits of its usefulness.

Effects on the Action of muscles.—The late Professor Parkes has shown the destructive influence of alcohol upon the power of muscular exertion. He induced three soldiers to take a march of 20½ miles, each carrying his full kit, weighing 51 lbs. They received either coffee, rum, or extract of meat with a little water. The experiment lasted six days, each man receiving one of the three fluids during two of the six days. All three men declared the alcohol to be the cause of early exhaustion, the meat extract being regarded the most valuable and sustaining for muscular work. For persons engaged in laborious work a moderate quantity—that is, less than an ounce and a half of alcohol—does not appear to have much effect, but where the quantity per diem exceeds two fluid ounces per day, the capacity for strong and sustained muscular work is manifestly lessened. This effect is probably due to the dulling of the nervous system, which renders the muscles less amenable to the will, and partly to the over-excitation of the heart, causing palpitation and breathlessness. Alcohol enables us to draw upon reserve energy, and may thus assist in a single effort of short duration, but it is absolutely harmful to any prolonged exertion. The trapper of North America abstains from alcohol during his day's tramp, although he frequently gets drunk in his hut at night. Exercise has an important influence in modifying the effects of alcohol. Those following sedentary occupations and dwelling in crowded towns cannot oxidise as much alcohol as those doing out-door work, and are therefore much more susceptible to the evil effects of alcohol on the body. The Scotch game-keeper, living and working on the Highland heath, may consume comparatively large quantities of his native whisky and still live to a ripe age—a quantity that would kill the city merchant within a few years. The Russian peasant, whilst leading his simple home life in his village, is addicted to taking "nips" of *vodki*, yet, as a soldier in the Russian Army, when on the march, he is not provided with alcohol.

Alcohol lessens the power of undergoing severe bodily exertion; it does not impart strength. Those who are going through a system of training for competitive feats requiring strength and physical endurance, such as walking, running, rowing, etc., usually eschew all alcoholic beverages, even if they have been previously accustomed to them.

What constitutes excessive use of alcohol.—Experiments have shown that an adult man, in moderate exercise, cannot use up more than 1½ ounces of alcohol within 24 hours. When the amount of alcohol is increased to 2 ounces in the day, *excess is reached.* The strength of the body is decreased, nutrition is rendered defective, and such alterations may take place as lead to disease of the liver, lungs, or kidneys. Any amount, therefore, exceeding 1½ ounces of alcohol a day constitutes an excess.

The maximum quantities that can be taken with any degree of safety are—brandy, whisky, gin or rum, 2½ ounces in the 24 hours; ¾ of a pint of light wines, clarets and hocks; or 1½ pints of ordinary beer, such as European soldiers use. This represents the quantity which first fails to produce any diminution of physical energy in the adult healthy man. Beyond these quantities it not only does no good, but the excess not utilised as food does harm. It is only exceptionally that alcohol is required as a food. *King's Regulations*, § 27, lays down that 2½ ounces of rum may be issued on field service when ordered by the G. O. C. on the recommendation of the P. M. O. It is highly probable that the best work of the soldier in the field can be done by total abstinence.

Men have been capable of the greatest bodily and mental exertion without alcohol, and in extremes of heat and cold they are undoubtedly better without it, provided that in the latter case, they have appropriate food.

Alcohol should never be taken on an empty stomach. Its best effects are secured when it is taken with the food. The use of alcohol during the middle of the day is to be discouraged in this country and its use during duty should be strictly forbidden.

Alcohol unnecessary in health.—Alcoholic beverages are unnecessary in health. Some people, however, find, by experience, that a small amount of some alcoholic beverage does them good, and adds to their comfort and well-being. In such cases the quantity of the beverage used in the day should not exceed the amount mentioned. The persons who for these reasons enjoy alcoholic beverages most, take them in strictly limited quantities, and usually with their meals, and there is no evidence to show that taken under these conditions, it does any harm to the system.

The use of alcohol in any form when actually marching should be stringently forbidden. If the issue of alcohol is considered permissible, it should be after the whole day's work has been finished.

We cannot in the light of present-day knowledge and experience condemn alcohol as an article that is always injurious. It is certainly useful in some diseased conditions, and is sometimes desirable in health. Service in the Army, as in most other callings, has its little cares and worries, and it is probable that, with some men, a small or moderate amount of alcohol taken with a meal after the day's work is over, may soothe the system, prevent waste of tissue, stimulate flagging energies, and help digestion. In the case of senior officers who have served many years in India, alcohol in small quantities is often a useful addition to the diet. When men are known to be inclined to abuse the use of alcohol, we should encourage and help them to become total abstainers. If they merely take alcohol within the limits stated above we are scarcely justified, in the present state of our knowledge regarding alcohol, in coercing them to total abstinence.

These are the main considerations that should guide our views in regard to the use of alcohol in the Army—they are unassociated with the extreme opinions of rabid supporters of teetotalism, they emphatically discountenance the abuse of alcohol, and give a freedom of action to those who can adhere strictly to moderation.

Use of Tobacco on the March.

Tobacco is generally used for smoking, less frequently for chewing and as a snuff. Whilst one would not say that tobacco is a necessity to the soldier, either in garrison or in the field, there is a general concensus of opinion among military medical officers that its moderate use in some cases adds to the comfort and happiness of those who indulge in it. The tobacco-smoker, when deprived of his pipe or other form of smoke, often feels the want of it more than he does of food. In moderation, after meals, tobacco-smoking seems to stimulate gastric secretion, aid digestion, tend to prevent constipation, and where the supply of food is deficient appears to diminish the sensation of hunger. "Korloff during the Russo-Turkish War of 1878, studied its properties minutely in regard to blunting the sense of hunger, and as a result he recommended that a daily ration of tobacco be issued to the Russian troops." In the Armies of the United States and Germany on field service tobacco is one of the components of the emergency and ordinary rations respectively.

When not to smoke.—Smoking during the heat of the day, particularly while on the march, increases thirst and leads to unnecessary drinking. The same result follows the chewing of tobacco on the march, due to the loss of salivary fluids caused by frequent spitting. Tobacco is used to overcome weariness, serves to relieve *ennui*, and on many of its *habitués* has a soothing effect. We know that in standing camps, during periods of inactivity and inertia, the monotony of life sooner or later jars and frets the soldier; during these periods tobacco is used

nominally to pass the time, but in reality as a calmative on the unemployed nervous system. Under such circumstance there is the risk of its being used to excess and of its producing harmful effects, and men should be cautioned about this.

What constitutes excessive use.—It has been estimated that in pipe-smoking the average consumption is something over half an ounce of tobacco a day, and that an ounce *per diem* is excessive. It is scarcely possible to state the minimum quantity that would be harmful to any one individual, but the occurrence of shortness of breath, palpitation, obscure pains about the region of the heart, nervous irritability with loss of appetite, are indications to reduce or temporarily abstain from the use of tobacco. More pronounced symptoms resulting from its use are—loss of appetite, impaired muscular energy, giddiness, alteration of vision, loss of memory, and progressive general weakness.

The enjoyment of tobacco-smoking has never been satisfactorily accounted for, and it is not even proved that nicotine is essential to the pleasurable results. The outcome of a vast amount of experimentation in connection with tobacco-smoking is that so far its effects are unexplained.

It is a curious fact that with many smokers, the pleasure of smoking is largely abolished when smoking in the dark or in a stormy wind and when the smoke is not seen.

One of the commonest effects of over-indulgence in tobacco is a chronic inflammation of the throat and upper parts of the respiratory passages, leading to hoarseness and excessive secretion of mucus from the mucous glands of these regions and a morning cough. This is explained by the constant action of an irritant alkaline vapour in the smoke, and not to the nicotine. A similar irritated condition of the tongue is frequently met with, especially when the hot vapour is directed on one part, as in pipe-smoking, and it is sometimes stated that the constant irritation thus produced in middle-aged people renders the tongue and lips more liable to cancer in these parts.

Dyspepsia, loss of appetite, and consequent loss of flesh may also be explained by the local irritation produced by swallowing the saliva. In the great majority of cases of chronic tobacco poisoning, the symptoms disappear on relinquishing the habit or even restricting the daily consumption.

The practice of cigarette-smoking has rapidly extended in this country and is doing a considerable amount of harm to the male part of the youthful population. Smoking of the *hookah* (in which the fumes first pass through a bowl of water at the bottom of the pipe), when the tobacco is pure, is probably one of the most innocent forms of tobacco-smoking indulged in.

Moderate tobacco-smoking by fully developed and fully trained soldiers does but little harm. When used in excess it is always injurious,

as it always is in untrained youths whose hearts are inordinately susceptible to its effects. Placed in the order of merit one would place the pipe, cigar and cigarettes. The last named is the worst form of smoking, and in the forms of cigarettes now largely imported into this country and used by our troops in India, which are made from the most villainous refuse tobacco in the American market, is very injurious. Last year one saw largely advertised a brand of cigarettes sold at 20 for 6 pies, in which the tobacco was uncured and half rotten. The form of cigarette-smoking that has sprung up in the Army in recent years should be discouraged in every possible way—it can do nothing but harm. The most injurious part of this habit is inhaling the smoke. The tobacco sold in cantonments, canteens, and coffee-shops should be closely watched and controlled.

Various orders regarding smoking have appeared from time to time, issued usually by commanding officers and general officers on their own responsibility, and from these one would abstract the following two. The first is with reference to the troops in the Irish Command :—

" The Commander of the forces has during recent visits to military hospitals been again struck by the harm that the increasing prevalence of cigarette-smoking is doing the health of the Army. It is not confined to the Army, and Parliament is likely soon to deal with it as affecting the national health. Lord Grenfell appeals to the Irish Command to give earnest and early thought to combat what is gradually, but greatly, affecting its efficiency, and he requires all commanding officers to impress on those under their command the evils that inevitably result from this excess. He would point out that in other directions the health and well-being of the troops in this command have greatly benefited from the loyal and intelligent co-operation of all ranks in giving effect to sanitary measures suggested by the medical authorities. He looks forward with confidence to a similar appreciation of his endeavour to mitigate the harm done by excessive cigarette-smoking, especially among the younger soldiers.

" With a view to helping men to overcome the habit, the commander of the forces directs the smoking of cigarettes to be prohibited at certain times when, on the other hand, no similar restriction as regards pipe-smoking will be made. The smoking of cigarettes, therefore, will not be permitted when men are on fatigue or under arms on any occasion, including field operations and manœuvres."

The following was published by the officer commanding a British unit :—

" It has been brought to the notice of the commanding officer by the medical officer and from other sources that a considerable amount of harm to the health of the battalion is being done by the very large amount of cigarettes that are being smoked by all ranks. The following order will be strictly adhered to from this date.

"Cigarettes will never be smoked by any officer, warrant officer, non-commissioned officer or man, when on any duty whatsoever, that is, when on manœuvres, field days, route marches, company parades, guard duties and fatigues, or when employed in any of the regimental institutes of any of the battalion offices, or when attending such offices."

It is an unfortunate circumstance that the habit of cigarette-smoking has grown very considerably both amongst our European and Indian troops in India. All boys in the service should be forbidden from smoking cigarettes.

The habit of passing the pipe from mouth to mouth should be stopped—disease is occasionally communicated in this way.

Tobacco-chewing by inducing spitting causes thirst and should be discouraged while actually marching.

Bathing on the march.

The normal secretions of the skin tend to accumulate on its surface, but the skin may be soiled in other ways—by the dust of the air and by coming into contact with such impurities as we may work in. All these have to be removed; if they are not, the functions of the skin are imperfectly performed and its work has then to be carried out by other organs. If the blood-vessels in the true skin are contracted by cold, they cease to supply the fluid and other bodies that go to form sweat. If the waste matters that are usually removed by the sweat are locked up in the body, we are rendered liable to various forms of disease. The pores of the skin, when in action, help to remove certain impurities from the surface which have been thrown off from the blood. The skin, in many diseases, is the main channel for getting rid of the disease poison.

Necessity for bathing.—All these facts point to the *necessity of bathing from head to foot at least once a day whenever this is possible.* The whole of the wonderful functions of the skin may be deranged, interfered with, or even suspended, through neglect of frequent ablution; inattention to this hygienic requirement seldom fails to produce disease.

No bath is complete without a thorough rubbing down of all parts of the body subsequently; this has a decided effect in improving the circulation of the blood.

Soap should be used frequently. It is indispensable for any bath taken for purposes of cleanliness. Some of the waste matters that cling to the skin are of a fatty nature. Fat does not combine with water, but soap easily mixes with the greasy material secreted by the sebaceous glands, uniting with it, and thereby enabling the water to wash it off. Soap is made up of fat or oil, combined with an alkali, which is usually soda, potash, or lime. In all soaps there is a certain amount of free alkali (that is, uncombined with the oil or fat), so that when soap is rubbed with water on the body, the spare alkali combines and forms a lather

with the fat of the surface, which is then easily removed. Cheap and good soaps are now made in many parts of India and there is little excuse for not using them.

Arrangements should be made wherever practicable for all men to have a bath when necessary, and when tanks, canals or streams are used for bathing in these, there should be a water-piquet on duty with ropes for use in case of necessity. European troops should be careful of the effects of the sun when bathing in this way.

Inculcation of habits of cleanliness.—It is necessary to reiterate the necessity of cleanliness of body and clothing by regular bathing and washing of clothes. From the date of his enlistment the necessity of personal cleanliness should be inculcated into the recruit, until the regular habit of being clean in his person and clothes becomes mechanical. The facilities for these operations on the march are often limited, especially when water is scanty and at a distance. Yet medical officers with corps should insist that every available opportunity is taken advantage of for bathing and washing the clothes, especially clothes worn next the skin. The numerous minor ailment—eruptions, irritations, parasitic cutaneous maladies, etc., arising from the unwashed skin, add to inefficiency. The bullets of the enemy coming into contact with men having clean skin and clean clothes have little to be feared unless they injure large joints or vital organs. The reverse is the case when a skin laden with septic micro-organisms is invaded. Modern surgery can do much, but it is incapable of assuring recovery in the case of wounds surrounded by and impregnated with all the potentialities for septic infection. We insist on the necessity of this cleanliness of skin and clothes in our annual course of first aids to the injured, and we point out the innocuousness of ordinary bullet wounds and sword cuts in the presence of our first field dressing, provided that no septic germs are introduced through skin and clothes.

Sanitary regulations and the laws of personal hygiene cannot be engrafted when on the march and on field service ; they must be inculcated in peace times. " The whole sanitation of an army depends in the ultimate issue on the individual effort of each person in that army." Our men should be taught to pride themselves in obeying all general sanitary orders connected with the camp, and all instructions given them regarding personal hygiene.

All ranks can help in preventing disease.—Every British and Native officer, and every non-commissioned officer, can help in preventing inefficiency from disease by seeing that men observe all sanitary and hygienic rules prescribed for their guidance and welfare on the march. Every officer of every unit, from the last joined subaltern upwards, has his personal responsibility in preventing disease in the men. The health of the force depends on the rigid observance of the sanitary precautions and rules laid down, and it is directly in proportion as commanding,

medical, and other officers of units insist on such observance, and devote personal attention to them, that the troops will remain free from preventable disease.

At the present time we are making efforts throughout the Army in India to educate British and Indian officers and all non-commissioned officers in sanitary matters affecting the health of the soldier in peace and war and in sanitary discipline. It is hoped that by the series of lectures and demonstrations that are being constantly given by medical officers to all branches of the service at the present day, education in preventive measures will rapidly spread, and that sympathy with and co-operation in sanitary organisation will soon become instinctive principles in the service.

Real and well-grounded sanitary discipline regarding the prevention of disease is of paramount importance throughout the Army. Sanitary discipline is as urgently necessary as fire discipline.

The company officer in the British service, the double company officer in the Indian army, and the section commanders in both, are the persons who are constantly with their men, and it is they who should become thoroughly familiar with the elementary rules of military sanitation and teach their men how to apply these rules. Personal hygiene should form part of the daily life of the soldier, and he should take a pride in avoiding all conditions and habits likely to cause sickness, and in adopting all possible means of preventing disease of any sort.