

## Editorial.

### TRENCH FOOT.

THE effects of cold in the form of frost-bite or gangrene of the feet have been recorded from ancient times. In 1812 Larrey described the effects of cold in Napoleon's Russian campaign. He seemed to be familiar with conditions experienced in the Great War. He pointed out that frost-bite did not occur when the temperature was steadily below zero, but was apt to appear when the temperature was variable, sometimes above, sometimes below, the freezing point. He said that heat suddenly applied might be the determining course of gangrene. In the medical history of the Crimean War it is stated that cases of frost-bite and gangrene occurred when the temperature was above the freezing point, and especially when there was rain, a cold north-east wind, and frost at night. Factors which helped to bring about the condition were lack of opportunity for changing the clothes, tight boots, fatigue, and defective nutrition. Diseases such as scurvy and "fever" were also factors in its causation. Owing to the conditions in trench warfare men could not move about to assist the circulation, and frequently had to remain at the bottom of a trench knee-deep in mud and water or half filled with snow. Similar cases of frost-bite were described by Davys and Powell Connor among the members of the British Mission to Thibet in 1903; in the Russo-Japanese War in 1904-5 by Macpherson; and again in the Balkans in 1912 by Max Page.

Severe cold, especially when combined with a high wind or a great altitude, produces frost-bite, a more sudden and ultimately more crippling disorder than trench foot. This true frost-bite is the dread of men attached to arctic and Himalayan expeditions and occurs in this country among airmen. Typically, days or even weeks of immersion in mud are needed to produce trench foot.

Colonel Gratton, who was D.D.M.S. of the IXth Corps in the War 1914-18, writes that on the Western Front troops, when carrying out reliefs, had to march several miles from their billets along wet and muddy roads, and as they approached the battle line the going became heavier and very trying to soldiers equipped in battle order. The troops arrived at the entrance to the communication trench more or less fatigued, bespattered with mud and wet; in the days before trench boards were in general use the effort of marching through a long communication trench, sometimes half a mile or more in length, was a feat of endurance which was attended with an immense expenditure of energy. When the men eventually arrived at their stations they had to remain there with little power of movement owing to the depth of liquid mud often at the freezing point.

During the winter of 1914-15 troops might have to remain in their trenches for weeks at a time. When reinforcements arrived in increasing numbers it was possible to arrange for a bout of duty of forty-eight to seventy-two hours in the front line, followed by a similar period in support, before returning to billets for five or six days in reserve. The men were given a

liberal supply of good food and were warmly clad. Also in 1914 it was found possible to supply charcoal braziers in some parts of the line. In some sectors, owing to the waterlogged state of the soil the trenches were merely crumbling earthworks. It was not until sufficient material was available for revetments that it became possible to move in the trenches in comparative safety. In the waterlogged country east of Ypres it became necessary to lay down miles of trench-board tracks before the troops could reach the trenches reasonably dry shod.

As the British front gradually extended in a southerly direction the nature of the subsoil changed from clay to chalk, with the results that the hardships from waterlogged trenches were greatly diminished, and a much greater degree of protection was attained by the provision of dugouts which could be constructed without great difficulty in the solid chalk.

True frost-bite is usually, though not always, of quicker onset. The usual burning sensation of great cold dies away and all sensation in the affected part is lost. At this stage the skin is white; either waxy or sometimes, when the surface is completely exposed, like skin sprayed with ethyl chloride. When fingers and toes are involved the joints become stiff. Thereafter, complete recovery may take place; or after a variable time neuralgic pains may begin. The skin is usually hypo-æsthetic. The nails may fall off and the new nail is malformed for a time. Gangrene of the skin or deeper structures may develop.

Trench foot is generally supposed to be caused by cold, wet, and the effects of pressure. Bacterial infection noted by French, Italian, and British observers has been regarded as a secondary infection resulting from the lowered resistance of the tissues.

In 1900 Rischpler published an account of a research he had carried out. He considered the whole of the phenomena observed were due to inflammation caused by cold. There was early œdema; the cells in the walls of the vessels were swollen and degenerated; the bundles of connective tissue were swollen; the muscle fibres in the media of the arteries showed vacuolation; there was little sign of thrombosis in the vessels, and in general the effects could not be ascribed to thrombosis.

As a result of their experimental work on animals and clinical observation, Lorrain Smith, Ritchie and Dawson concluded that the essential change consists in damage to the blood-vessels; this is manifested by swelling of the endothelial cells of the vessels of all kinds and by the vacuolation of the muscle fibres in the arterial walls. An excessive amount of fluid is consequently poured out into the tissues and in some cases the vessels rupture and hæmorrhage occurs. Along with the injury to vessels there is also an interference with the vitality of the cells of the surrounding connective tissue. Evidence of this is found in the readiness with which fibrin formation occurs in the exuded fluid as contrasted with its absence in the form of thrombi in the blood-vessels. As regards the condition in man these observers drew special attention to the effects of pressure and constriction. They noted that in all the cases seen the lesions were confined

to the feet and were specially likely to occur in the part where corns and callosities were common, that is to say on the inner and outer aspects of the toes, over the joints on the anterior part of the foot, and on the heel.

The D.M.S. of the First Army stated in his diary on January 7, 1915: "Noted during visits to the C.C.S. grave condition of men coming in with sore feet and found in most cases boots had never been off or even unlaced for days, sometimes weeks, at a time, and that no dry socks were carried."

A lowering of hæmoglobin as estimated by Gower's hæmoglobinometer, in patients suffering from "chilled" feet, was noted by Major Gray when in charge of No. 2 Mobile Laboratory. In an average of 25 controls he found the percentage of hæmoglobin to be 85.5, whereas in the patients with chilled feet the percentage worked out at 77.82.

The general opinion that trench foot is due to cold and impeded circulation was disputed by Médecin-Major V. Raymond and Médecin-Major I. Parisot of the French Army. They claimed to have isolated from the lesions a fungus which was identified by Vuillemin as *Scopulariopsis noninjii*, and found in litter, straw, and manure. They stated that cultures of this fungus, when inoculated into animals, produced all the symptoms of trench foot. They considered the condition was due to infection from the mud in the trenches. At a meeting of the International Congress of Hygiene held in Paris in November, 1919, Dr. Roux, Director of the Pasteur Institute, stated that the conclusions of Raymond and Parisot were not generally accepted, and that their observations had not been confirmed. The consensus of opinion was that trench foot was caused by wet, cold, and conditions which interfere with the circulation in the feet.

The workers in the Clinical Research Department at University College have added to our knowledge of the reaction of the skin to cold. Their work has given a possible explanation of the action of mud in producing at comparatively high temperatures damage nearly akin to frost-bite. Lewis and Love have shown that the skin begins to freeze when its surface temperature is reduced to a point between  $-2.2^{\circ}$  C. and  $-25^{\circ}$  C., the wide variation being due to the factor of super-cooling—the capacity, that is, to go below freezing point without solidifying—a factor which varies with different people. Super-cooling does not harm the skin, prolonged freezing does. The capacity to super-cool may be abolished by soaking the skin in water; the skin which does not super-cool may be induced to do so by leaving it unwashed for a week, or by rubbing in olive oil, an observation that gives authority to the use of whale oil.

At altitudes above sea-level the effects of a low pressure of oxygen are important. The increased pulse-rate has been shown by Doi, Schneider, and Barcroft, to be a sign of distress and is accompanied by a reduction of the minute volume of the heart. When the supply of oxygen is deficient the skin bears the brunt and may be predisposed to frost-bite; there is no doubt that oxygen should be administered at the earliest possible moment in any case of frost-bite above sea-level on a mountain or in an aeroplane.

The greatest wastage from trench foot occurred on the Western Front

in France and Flanders; there was also serious wastage in Gallipoli and Macedonia. According to the statistical branch of the Medical Research Council frost-bite among the British in France and Flanders was as follows: August, 1; September, 1; October, 41; November, 1,555; December, 4,823. The term "trench foot" does not appear to have been generally adopted until the end of the winter 1914-15. In December, 1914, eight cases diagnosed trench foot were admitted to hospital.

In the First Army there were more than 3,000 cases of trench foot between December, 1914, and February, 1915, but after strong disciplinary measures had been taken in the First Army to prevent the occurrence of trench foot, from the middle of January onwards the disease became more or less negligible at a time when it continued to have a very high incidence in the Second Army in the sectors of the Ypres salient. The war diaries give some indication of the incidence of foot troubles in Gallipoli during the period November 25 to December 20, 1915, but the number of admissions was much greater than shown, as many diaries simply stated that "many" or several admissions occurred without giving any numbers. The figures given were: Frost-bite 3,607, trench foot 1,322.

In Macedonia from November 29, 1915, to April 4, 1916, 962 cases of frost-bite and 336 cases of trench foot were admitted to hospital. Of the former 767 occurred during the week ending December 4, 1915.

In slight cases of trench foot there may be no abnormal appearance, but there is severe pain and acute cutaneous hyperæsthesia, which may persist for several weeks. The skin is first white then mottled and bluish red, or the whole foot may be red and swollen resembling a large chilblain, to which affection trench foot of this degree is very closely allied. In severe cases the foot is always swollen and the swelling may extend to the knee. In these cases the whole foot is absolutely numb at first, but becomes very painful after a few days' rest in a billet or field ambulance. It was quite common for men to have no feeling that there was anything wrong with their feet while in the trenches, even though the toes were already dead. In some cases blisters occur and they may be large and numerous. In still worse cases the toes may be purple or black. In many cases the blackness did not mean deep gangrene and most of the toes recovered. In a few cases the toes died, and in a very few cases the whole foot became completely gangrenous. Subjects from trench foot often developed tetanus. Bruce drew attention to the importance of prophylactic injection of anti-tetanus serum. He wrote "the disease wastes no time in local manifestations but bursts out as generalized tetanus and runs an acute and fatal course in twenty-four to forty-eight hours."

The treatment of the acute stage when the affected part is regaining its warmth is important as it is recognized that heat greater than that of the human body is harmful. The danger of fires, hot-water bottles, and hot-water baths is obvious, for the stagnant circulation is incapable of carrying away this heat. Smith, Ritchie and Dawson showed that water at 37° C. will cause rapid œdema. Lewis and Love have shown that transudation

may be excessive and have even suggested obstructing the circulation in the frost-bitten parts during the stage of thawing. Raymond Greene considers that rubbing the affected parts even with snow is dangerous. Apart from the danger of increasing the congestion there is the possibility of further harm to the damaged tissues.

In the treatment of slight cases of trench foot it is only necessary to allow the patient to lie down so as to keep the feet elevated. In all cases the affected part must be carefully and gently cleansed and wrapped in dry sterile dressings and many layers of wool.

An injection of antitetanus serum should always be given. Alcohol should not be given owing to the peripheral dilatation it produces. The patient should be given hot drinks and removed to a place of comfort. Bullæ should be punctured and dressed with some antiseptic. In later stages slight cases are stated to be benefited by short-wave treatment.

Gangrene of the toes is best treated by amputation of the toe or toes after a week or more has been allowed for the circulation of the foot to improve.

In the case of apparent gangrene of the foot it is never right to amputate at once, for in the majority of such cases most of the foot recovers. If the gangrene is dry it is well to wait for "a line of demarcation," but if moist it is often necessary to amputate earlier. It must be remembered that the line of demarcation is often late in forming, and the skin may be destroyed over a wider area than the deeper tissues.

In 1914-18 the prevention of trench foot consisted in maintaining the men in as fit a condition as possible. The particular measures were the protection of feet and legs from mud and wet and keeping them dry, warm, and clean, in fact making a fine art of the toilet of the feet; improving the condition of the trenches; and providing the men with hot food. Special clothing and special boots were issued; large sizes of Service boots were necessary to counteract the shrinkage caused by wet and also to allow the men to wear two pairs of socks. Gum-boots with thigh extensions were issued, and in order to avoid the necessity of walking a greater distance than necessary gum-boot stores, where the articles were issued to the men and where they left their boots, were selected as close to the firing line as possible. In exceptional cases these stores were located as near as 1,000 yards to the front line in a dug-out excavated from solid chalk, but usually they were at a greater distance, about 5,000 yards or more. When gum-boots were used for marching the inside of the boots became wet from condensed perspiration and the breeches or trousers protected by the indiarubber extension became soaked from the same cause. Gum-boots had to be dry inside when issued from the stores. This was effected by driving hot air into them through a pipe fitted with rubber tubing through which the hot air was blown right to the end of the boot. Two pairs of woollen socks were recommended to be worn and the gum-boots had to be large enough to allow the socks to be worn with comfort. If the straps at the ankle were carefully adjusted the wearer could walk without the heel slipping

up and down inside the boot. It was advised that the boots should not be worn for more than thirty-six hours. Many officers stated that they obtained the greatest benefit from gum-boots when they put them on in the trenches. They preferred to walk up in their ordinary boots and change on arriving at their destination. For the supply of dry socks to men in the trenches "divisional sock stores" were formed under the charge of the "baths officer." Waterproof bags full of clean dry socks were sent up to the trenches every night with the rations in sufficient numbers to allow every man to have a fresh pair of socks every twenty-four hours. The dirty socks were sent down by the same route, and were collected and sent to the laundries daily. In order to maintain the circulation in the feet and legs men were encouraged to move about in the trenches. Other measures were the removal of boots and foot-rubbing drills with massage.

Rest and recuperation in a correct posture when off duty were important factors in preventing trench foot. If the men were then left to themselves and allowed to spend their time in a crouching position on the side of the wet trench or sitting on the fire step, then the time off duty increased the liability to trench foot. Captain Hughes, writing of his experiences as a regimental officer, attributed cases to the habit men had of sleeping in a sitting posture on the fire-step of the trenches. The sharp edge of the trench pressed on the popliteal space and induced coldness of the feet. He arranged that when men were on duty in pairs the man whose turn it was to rest should lie with his feet up on the fire-step and sleep in his greatcoat and two blankets, his own and that of his comrade. The result of these measures was that no cases occurred in twelve days of inclement weather in the battalion under Captain Hughes' charge.

The supply of a liberal ration of hot food in the trenches did much to counteract the harmful effects of exposure. The ordinary camp kettle full of hot stew was placed in a hay-box which was slung on a pole and carried by two men up to the trenches. After the soldier had filled his mess-tin with stew this was heated up by means of a "Tommy's cooker," a small stove in which solidified alcohol was burned. Brigade soup kitchens were also organized, and were located close to the gum-boot stores, where men were given a cup of hot soup when changing their boots. Troops coming out of the trenches were served with hot soup in the same places.

Experiments were made with foot-grease and powders, but whale oil was preferred and was rubbed well into the feet until the skin was practically dry. The objections were its offensive smell and uncleanness. Later on the method advocated by Médecins-Major Raymond and Parisot of the French Army was adopted in place of the oil. Before going into the trenches the men washed and dried the feet thoroughly and then applied a powder of borated chalk and camphor which was also dusted inside the socks. When in the trenches the men wore gum-boots and were provided with a daily change of clean socks.

"Foot-washing centres" were an unqualified success and constituted an important link in the chain of preventive measures; they were much

appreciated by all ranks. After leaving the trenches no time must be lost in making the men as comfortable as possible; their clothes should be dried and arrangements made for baths and a change of clean clothing. It should be remembered that as much harm may result from men waiting about in billets with sodden boots and socks as if they were actually in the trenches.

By the adoption of these preventive measures immediate results were obtained, and trench foot practically disappeared from all the divisions of the First Army except one. When inquiry was made, it was found that the battalion medical officer and not the company officer had been made responsible in divisional orders for the preventive measures. When this was rectified, good results were at once obtained. This incident emphasizes the importance of placing the responsibility for the proper care of the men's feet on the company and platoon officers.

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#### REFERENCE LIBRARY FOR THE MEDICAL BASE IN FRANCE.

THE Royal College of Surgeons are providing a Reference Library for the Medical Base in France.

We are informed that the library will include provision of the current issues of over forty scientific journals, as well as a large collection of volumes, to be kept up to date, covering the fields of surgery, medicine, pathology, and the allied sciences. It will give those who are working to improve the known methods of medical treatment ready access to the literature of their subject, and will enable medical officers in general to keep abreast of advances in professional knowledge.

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#### THE ROYAL INSTITUTE OF PUBLIC HEALTH AND HYGIENE.

THE Executive Council of the Royal Institute of Public Health and Hygiene has appointed Lieutenant-Colonel J. S. K. Boyd, M.B., B.Ch., D.P.H., R.A.M.C., to deliver the Harben Lectures for 1940.

His subject will be "Modern Practice in War-time Immunization of Soldiers and Civilians."

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#### THE HARBEN GOLD MEDAL AND SMITH AWARD.

THE Executive Council has decided to award the Harben Gold Medal for 1940 to Sir Leonard Hill, F.R.S., LL.D., M.B., and to confer the "Smith Award" for 1940 upon Sir William Savage, M.D., M.R.C.S., D.P.H., late Medical Officer of Health, County of Somerset.

The Harben Gold Medal is, in accordance with the terms of a Trust created by the late Sir Henry Harben in 1894, awarded triennially to one, irrespective of nationality, who has, in the opinion of the Council, "rendered eminent services to public health."

The "Smith Award" consists of a bronze figure of Hygeia, and is awarded triennially to a medical officer of health who has, in the opinion of the Council, "achieved most noteworthy work in the discharge of his duties."