If we examine a person lying in the horizontal position we find the head of the femur at least three inches above the tuberosity of the ischium; whereas, when sitting up, the femur is at right angles with the axis of the body. These two points are on the same line, perpendicular to the femur, one above the other.

As the body moves on the extremity of the ischium in assuming the sitting posture, the head of the femur must be pushed downwards for two or three inches. This must influence the point of weakest resistance—the seat of fracture. This, if the fracture be oblique, will have the tendency to cause the fragments to slide one over the other; or, if the fracture be transverse, and the fragments accurately applied to each other, will force them to assume a more or less obtuse angle.

Hence, I think we cannot be too careful in frequently inspecting the position of the limb, especially while the union is yielding and soft, and offers an objection to putting up these fractures in immovable apparatus, which can only conceal the deformity, but cannot prevent it.

ART. XIII.—*The Work and Rations of the Soldier.*^a By
J. HICKMAN, Army Medical Staff.

SECTION I.—THE WORK OF THE SOLDIER.

IN comparing the value of foods as force-producers, it has been shown^b that all work must be reduced to the one common standard, expressed in foot-tons. Though the object of this section is the consideration of external work, it may be useful to make a few remarks on the work done by the heart, and generally the automatic labour of the body, especially, too, as this internal work seems to increase proportionally with the external. On an average the heart makes 70 strokes a minute, discharging at each stroke about $1\frac{1}{4}$ ounces of blood against a pressure of over 4 lbs. per square inch, and consuming an amount of energy in the 24 hours of 124 foot-tons. The quantity of air pumped in and out of the lungs in 24 hours varies from 400 cubic feet, when no exertion is being made, to 900 cubic feet in the case of the hard-working labourer. It has

^a Since this article was written, an admirable paper by Colonel Onslow on "The Physical Training of the Soldier" has appeared in the Journal of the Royal United Service Institute, and should be consulted. The reader is also specially referred to Parke's "Practical Hygiene," 1887, pp. 239–253.

^b See Dublin Journal of Medical Science for July, 1888.

been calculated that the work which has to be performed by the muscles in the act of breathing amounts to 11 to 21 foot-tons in the 24 hours.

These two instances are sufficient: digestion and the different processes of life involve also so much expenditure of force; in the nourishment of the schoolboy and young recruit the energy requirements of growth should not be forgotten in the selection of a dietary. The total internal mechanical work of the body may be assumed to be an average of 260 foot-tons.

The external work varies so much; a country postman, 150 lbs. in weight, walking his daily round of 20 miles, would do work equal to 353·4 foot-tons; ordinary day labourers, such as we see in the roads, probably average 350 foot-tons. In Weston's feat of 50 miles a day, his daily work was no less than 793 foot-tons. In the six-day contest between Weston and O'Leary, the latter did over 1,900 foot-tons every 24 hours. Gale's accomplishment of 1,500 miles in 1,000 hours amounts to the enormous endurance of 560 foot-tons a day for six weeks continuously.

The maximum for ordinary men is 600 foot-tons, and this cannot be continued for more than a few days. Perhaps a classification might be made:—

Light work	-	-	150-200 foot-tons per day
Average „	-	-	300-350 „
Hard „	-	-	450-500 „
Laborious „	-	-	500-600 „

Taking the principal work of the soldier to consist in marching, walking at 3 miles an hour is equivalent to raising $\frac{1}{20}$ th part of the weight of the body through the distance walked.

Using this calculation, and assuming a man to weigh 150 lbs. with his clothes, we get the following tables:—

Kind of exercise	Work done in tons lifted 1 foot
Walking 1 mile - - -	17·67
Do., and carrying 60 lbs. - -	24·75

It is thus seen a light day's work would be from 8 to 10 miles, and an average day's work from 16 to 18; laborious work would be represented by about 30 miles walk a day, and practically could hardly be continued for long. A march of 10 miles with a weight of 60 lbs. (which is nearly the weight a soldier carries when in marching order, but without blankets and rations), is an average day's work. 20 miles' march with 60 lbs. weight is a laborious day's work.

In heavy marching order, with great coat and valise, &c., his weight will amount to nearly 200 lbs., and with this weight each mile will be equal to 23·6 foot-tons.

Taking all the duties, 300 foot-tons is a fair estimate of the daily work of the soldier. When dietaries are constructed for a large body of men this amount may be accepted as a standard.

A soldier's drill without arms is estimated as one-third more fatiguing than ordinary walking; in calculating punishment-drill allowance must be made for the fact of its being punitive, which increases considerably its exhausting effect.

Now, having arrived at the true meaning of a day's work, and, as previously shown, this only represents the $\frac{1}{3}$ th or less of the available energy to be provided, the amount of necessary food can readily be arrived at; if the work or strain is increased, this proportion becomes even less. In calculating the work undergone in marching, the ground must not be supposed to be even, and the weights of the accoutrements are hardly ever adjusted correctly. The attitude of the soldier is stiff, and even marching at ease he observes a certain rhythm in his steps and a uniform pace; a pedestrian varies his steps and his pace, and so takes the strain off. The speed or rate of going must be considered, for every mile of additional velocity the resistance is increased about one-fourth. In the case of the soldier, if he were allowed to march easily, and if the weights were not oppressively arranged, he ought to do 12 miles daily for a long time, provided he was allowed a periodical rest.

So much for marching. The duties of the soldier include drills, parades, sentry or guard picket, orderly and various fatigues, the cleaning of clothes and accoutrements, and they are varied by route-marches, gymnastics, musketry, or some other form of military exercise. In time of war the work is much more arduous, requiring an excellent physique to carry it out successfully. When an infantry soldier has finished his recruit's drill his work becomes comparatively light, and it would seem difficult to contrast this work with the ten hours' labour in the fields. The training of the recruit consists of four hours' drill a day, and this amount does not seem excessive, but the strain is greater than it appears; it is the difference between having a certain amount of work and having it compressed into four hours—the speed is increased and so is the strain. If the calculations were made exactly, the four hours' drill would perhaps equal the day's work of the agricultural

labourer. Even standing at attention is a constrained position; this and the various exercises bring into action fresh sets of muscles and so increase the fatigue; the heart, lungs, &c., have been fashioned under entirely other circumstances and occupations which enabled them to perform their functions in another manner than now called upon for the exceptional exercise of drill. Guard duty is important in keeping troops up to efficiency; by its mere action in breaking and shortening the times of rest it has a more or less wearing effect. The fact of non-commissioned officers and the band sending so few to hospital is accounted for by their exemption from this duty. Off parade the life of the soldier is an essentially active one; the different amusements and occupations for his leisure hours leave him little time for sitting down or resting—in fact, duties and vigorous field sports in the day time require ample time for sleep, and the value of recreation may be abused; the policy of extending the hours for passes at night is a doubtful one.

This sketch is only meant to give an idea of the routine work in time of peace; the description would have to be modified to apply to any special part of the army; the work of mounted branches is naturally much harder, and involves the expenditure of much more time and energy. The question of war duties will not be discussed; it would be impossible to come to any estimate of the work involved; the outline given above is sufficient, and includes a general idea of work under any condition.

Since time of peace may be looked upon as resting and repairing waste before a campaign, the duties then should be undertaken with the object of fitting the soldier to bear toil and exposure; by improving his bodily health and physique he is the better able to endure fatigue and hardship. It is right and fitting that a certain amount of storage material or balance should exist in the constitution of every healthy man. Every healthy individual possesses such a stored amount of force which will stand him in good stead when a demand arises for prolonged unusual exertions, or when any period of enforced starvation occurs, as during a lingering fever or other exhausting disease.

This reserve fund is specially important in the soldier to fall back on in the trials of service in the field, or to counteract the various depressing effects of climate and disease to be met with in his tropical experience.

It must be now understood that the exact and precise balance between food and work must be qualified by providing for not

only the amount of force employed for the purpose of daily life but also for a natural amount of store or reserve.

SECTION II.—FOOD OF THE SOLDIER—ITS ADJUSTMENT IN PEACE.

The conditions of a perfect dietary are supposed to consist in (Letheby):—

(1) The determination of the real wants of the body under different circumstances of age, labour, and climate; (2) a proper selection of food as regards quality, nutritive power, appetising property, digestibility and price; (3) the association of foods in such wise as not to offend the appetite or burden the digestive powers; (4) a right treatment of them by cooking, so as to render them useful to the system; (5) a just distribution of the daily diet in appropriate meals.

These remarks especially apply to the soldier, who, as a machine, must be kept in good repair, and sufficient motive power supplied. A deficiency means diminished strength and impaired strength, which, for a time, if not permanently, incapacitate the individual and render him unable to fulfil his duties. As before stated, work must be evolved from the food and not from the framework of the body. Individuals vary so greatly in temperament, mental power, and bodily activity, and capacity of digestion, that the principle of a general ration is hardly scientific. In soldiers who are about the same age, and whose duties are uniform, it is not necessary to consider this point. In a regulated and monotonous diet variety of cooking should answer for the variety of food. The substances are changed by the different processes, and the digestive powers differently stimulated. The respective amounts should also be modified by climate and exposure to cold, and also with the degree of muscular work performed.

Now the broad question of the standard ration presents itself, and it is not possible to treat the subject with originality. The observations and data are carefully recorded in most books on food.

The subsistence diet—that is, the food necessary for existence—is given by Playfair:—

	Ozs.	In foot-tons.		
Albuminates	- 2·	346	}	Nitrogen - 138 grains
Fats	- - 5	189		Carbon - 2,969 „
Carbohydrates	- 12·	1,656		Salts - 219 „
Salts	- - 5	-		
	<hr/> 15·0	<hr/> 2,191		

water-free. Allowing for water this would represent about 25 to 30 ounces of food. Parkes thinks on this men would show signs of weakness and lose weight.

Average daily diet of men in quietude (Parkes) :—

	Ozs.	In foot-tons.		
Albuminates -	2.5	432	}	Nitrogen - 172 grains
Fats - -	1.0	378		Carbon - 3,260 „
Carbohydrates -	12.0	1,656		Salts - 219 „
Salts - -	.5	-		
	16.0	2,466		

This diet represents quietude; to it must be added the foot-tons necessary for productive work.

Dr. Letheby gives the following as the amounts required daily by an adult man for idleness, for ordinary labour, and for active labour :—

Daily Diet for	Nitrogenous. oz.	Carbonaceous. oz.	Carbon. grs.	Nitrogen. grs.
Idleness -	2.67	19.61	} = {	180
Ordinary labour -	4.56	29.24		307
Active labour -	5.81	34.97		391

Tables from *Sanitary Record* (A. and B.) corrected :—

TABLE A.—*Ordinary Ration of the Soldier.*

Articles	Quantity taken daily in ozs. and tenths	Water	Nitrogenous substance or Albuminates	Fat	Carbo-hydrates	Salts
Meat - - -	12.00 (of which $\frac{1}{3}$ is bone)	7.30	1.44	0.81	—	0.154
Bread - - -	24.00	9.60	1.92	0.36	11.81	0.312
Potatoes - -	16.00	11.84	0.32	0.02	3.36	0.024
Other Vegetables (taken as Cabbage) -	8.00	7.28	0.14	0.04	0.46	0.056
Milk - - -	3.25	2.82	0.13	0.12	0.16	0.016
Sugar - - -	1.33	0.04	—	—	0.12	0.007
Salt - - -	0.25	—	—	—	—	0.250
Coffee - - -	0.33	—	—	—	—	—
Tea - - -	0.16	—	—	—	—	—
Total Quantity -	65.32	38.78	3.95	1.35	17.08	0.819

TABLE B.—Showing the Proximate and Ultimate Constituents of Diets, their Potential Energy and their Relative Proportions.

Constituents	Moleschott			Pettenkofer and Voit			(c) Mean of Previous Two taken as a Standard			Ranke		Soldier's Rations		Mean Ratios of Moleschott, Pettenkofer and Voit, and Ranke		Difference between the mean and the Soldier's Ration		Mean of Three Diets
	Water- free weight	Ratio	Alb.= 1·00	Water- free weight	Ratio	Alb.= 1·00	Water- free weight	Ratio	Alb.= 1·00	Water- free weight	Ratio	Water- free weight	Ratio	Alb.= 1·00	Alb.= 1·00	Actual	Per cent.	
Albuminates -	Oz. 4·59	1·00	1·00	Oz. 4·83	1·00	1·00	Oz. 4·70	1·00	1·00	Oz. 3·52	1·00	Oz. 3·95	1·00	1·00	1·00	-	-	4·31
Fats -	2·96	0·64	0·85	4·12	0·85	0·75	3·54	0·75	0·83	3·52	1·00	1·35	0·37	0·83	0·83	-0·46	-55	3·85
Carbohydrates -	14·26	3·11	2·57	12·40	2·57	2·85	13·40	2·85	2·40	8·46	2·40	17·08	4·69	2·69	2·69	+2·00	+74	11·61
Salts -	1·06	0·23	0·22	1·06	0·22	0·23	1·06	0·23	0·30	·89	0·30	0·81	0·22	0·25	0·25	-0·03	-12	1·06
Total -	22·87	4·98	4·64	22·41	4·64	4·83	22·70	4·83	4·70	16·39	4·70	23·19	6·28	4·77	4·77	+1·51	+32	2·083
Nitrogen -	Grains 321	-	N. to C. -	Grains 338	-	N. to C. -	Grains 330	-	N. to C. -	Grains 246	-	Grains 276	-	N. to C. -	N. to C. -	Excess of C. -	Excess of C. -	302
Total Carbon -	4,737	-	-	4,817	-	-	4,777	-	-	4,570	-	4,588	-	-	-	-	-	4,708
Salts -	464	-	-	464	-	-	464	-	-	390	-	356	-	-	-	-	-	430
Total potential energy in foot tons	3,878	-	-	4,103	-	-	3,990	-	-	3,015	-	3,542	-	-	-	-	-	3,665

Moleschott's ration may be taken to represent the standard average diet for a man doing a good day's work of 300 foot-tons. The soldier's diet is much below this standard, and it is a diet, in short, on which only a moderate day's work of 150 to 200 foot-tons could be demanded. Even if a quarter of a pound of meat were added to the existing ration the result would only then equal in potential energy Moleschott's calculation that is sufficient for average work.

Table B really represents the complete examination and comparison of the existing ration. At the side has been added the mean of the three standard diets. Especially attention is to be paid to Moleschott's diet and the one approaching it, marked (a), and they should be contrasted with the soldier's ration. They give about 1,700 foot-tons above the subsistence diet, and 1,500 above the rest. If there is true sympathy and co-operation of the tissues with the food supplied Helmholtz's proportion of $\frac{1}{5}$ available energy would give a good day's work, and the diets might be accepted as standards. The amount of carbon may be a little too high; the proportion of it to nitrogen, 15.1, is fairly maintained. The soldier's ration can thus be seen to be short of these standard diets by about 300 foot-tons. The amount of albuminates is too small, and the excess of carbohydrates, nearly 30 per cent., is too great a strain on the digestive system. The marked deficiency in the fats is to be noticed. In the two diets chosen for comparison the fats even are rather small. Pettenkofer and Voit's estimate is more liberal. In a later book Voit considers it better for the working man to take $12\frac{1}{2}$ ounces only of carbohydrates, making up the rest, that is, about 7 ounces, with fat. In the section on the alterations in rations this subject will be resumed. In fact, the adjustment of food includes the suggestions for improvements in any permanent dietary.

	English	French	German	Austrian	United States, Active Service	Standard
Albuminates -	3.86	4.33	4.02	3.73	4.99	4.6
Fats - - -	1.30	1.27	1.09	1.64	4.09	3.0
Starches - - -	17.43	18.04	19.62	17.00	15.26	14.3
Salts - - -	.81	1.00	1.50	1.0	1.23	1.1

It might be considered an addition if the peace ration of the

different European armies were given. They may afterwards be tabulated for reference. A table of their comparative constituents is appended.

The want of fats in the European rations is remarkable. The United States dietary is a liberal one, and to be recommended.

In conclusion, the estimate given in most works on physiology, and calculated from the balance of the economy, is, that man requires a diet in which the nitrogenous is to the non-nitrogenous as 1 : 4, and which may be summed up 300 grains of nitrogen and nearly 5,000 of carbon for ordinary work. For every additional foot-ton one grain of nitrogen and 16 grains of carbon should be added, and the extra work requires extra available energy in the form of albuminates and fat.

Alcohol in any form being included in a peace ration (as at Hong Kong) cannot be recommended; the amount of energy yielded by safe doses is very little, and when partaken of in doses beyond a certain amount it is certainly injurious to the body. If given as a food capable of being burned in the body it is necessary to insist on its dilution with 90 per cent. of water, or to select a compound where this condition is fulfilled, and to further advise it to be taken with the principal meal of the day.

In hot climates spirits are even more hurtful, for medical reasons which we need not give. It is doubtful whether alcohol increases mental power. Sir William Gull affirms positively that it does not. Experiments prove that more than two fluid ounces lessens the power of sustained muscular work. It was found, for instance, in the Ashantee campaign that, if taken during a march, it soon diminished vigour. The various diseases do not seem to be warded off by the use of spirits. The above remarks apply to spirits as an article of ordinary diet. It may, however, be contended that it is very useful as a restorative, even in health. At the end, for instance, of prolonged and severe exertion, either of mind or muscle, it is often useful; likewise when a person is chilled by wet. In disease there can be no doubt that spirits are frequently most beneficial. In conclusion, it is well to protest against the practice of those who, though never drunk, are continually tipping. The present fashion in soldiers of taking several times between meals a glass of beer is almost worse than getting absolutely drunk once or twice a week.

In war time, without doubt, the best beverages to work on are tea, coffee, or cocoa, and these should be supplied without stint.

SECTION III.—FOOD—ITS ADJUSTMENT IN WAR.*

If the ration of the soldier in peace is hardly sufficient to sustain the tissues of a man in moderate work, it apparently cannot meet the requirements of field service. Harassing duties, want of sleep, the trials of season and climate, long marches, camping out, anxiety and engagements with the enemy, all afford a degree of hard work unknown in garrison life. The losses of his organism are consequently greater, and to maintain the equilibrium the ration must be proportionately increased. Apart from sentiment, a man on service who is not well nourished eventually is sent to hospital, and as a fighting unit is lost to the army. When a campaign is entered upon in any country a scale of rations is fixed, and this is subject to modification according to the supplies afforded by the country itself. Provision is made for the issue of special rations in times of hard fighting or extra fatigues. As before pointed out, the increase should take place mainly in the nitrogenous and fatty elements. Fat bacon, cheese, peas, beans, and rice should be given, so as to bring up the nitrogen and carbon to the required standard.

It is not possible to make any general observations on the feeding of troops on field service without taking into consideration the uses of preserved and concentrated foods and the prevention of scurvy.

Theoretically taken into consideration the arduous duties of troops in warfare, provision should be made for a minimum of 350 to 400 foot-tons, and, if necessary, on occasions for 500 foot-tons a day:—

For work of 450 to 500 foot-tons per diem, ounces Avoir. per lb. of bodyweight					
Albuminates	-	·047	}	Nitrogen	= 450 grs.
Fats	-	·030		Carbon	= 6000 "
Carbohydrates	-	·120		Salts	= 500 "
Salts	-	·010			
<hr/>					
·207					

Equal in potential energy
to about 5,000 foot-tons.

This estimate is ample, and may be accepted as a standard of comparison. The food in time of war is not good in quality, and will hardly yield the proper amount of potential energy. A liberal allowance is more than justified.

* Diseases in war, arising from improper food, general feebleness, and increased liability to malarious fevers, dysentery, diarrhoea, &c., and productive of scurvy and scorbutic dysentery. At the battle of Solferino the Austrian soldiers were starving, and easily defeated. The Commissary-General had decamped with the treasure-chest.

[To be continued.]