On Improvements In Helmets And Other Head-Dress For British Troops In The Tropics, More Especially In India

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The Chairman said that he had the pleasure to introduce Mr. Julius Jeffreys, formerly Staff Surgeon of Cawnpore and Civil Surgeon of Futteghur, who had been kind enough to come there for the purpose of giving an account of his proposed improvements in the clothing, tent, and housing of British troops in the tropics. It was a subject, with many others of a sanitary character, which in the present age, in connection with the position of the British soldier, was gradually increasing in importance. Means such as Mr. Jeffreys brought forward, such as Mr. Sidney Herbert brought forward a short time ago, in the shape of sanitary improvements in the army, were gradually raising the comfort of the British soldier, improving his health during peace, and making war as easy to him as possible under the novel circumstances in which he then became placed. There was no doubt that the subject which Mr. Jeffreys was about to bring before them, The Clothing and Housing of Troops, especially in the Tropics, where special clothing and special housing were required, was calculated to be of great service to the army.

Mr. Jeffreys then read his paper, as follows:—

ON IMPROVEMENTS IN HELMETS AND OTHER HEAD-DRESS FOR BRITISH TROOPS IN THE TROPICS, MORE ESPECIALLY IN INDIA.*

By Julius Jeffreys, F.R.S. formerly of the Indian Medical Staff.

Although occupied during the leisure hours of the greater part of my residence in India in experimental and statistical inquiries into the climate, arts, and resources of that country (for which objects I carried out with me, on entering the Indian service, a variety of philosophical apparatus), I have, since my return to England many years ago, maintained, till of late, so general a silence upon Indian subjects, that I cannot but feel how great must be the disadvantage under which I present myself before you.

In undertaking an address upon the Clothing, Tents, and Housing of British Soldiers in the Tropics, more especially in India, I need hardly observe, that the field to which my remarks will be chiefly confined is the sanitary section of each of these subjects, and to certain points only in that section. Before this section can be placed in such a position of efficiency

* The publication of this paper has been delayed, in order that a second paper by Mr. Jeffreys, On Tents and Barracks for English Troops in the Tropics, might be published with it; the manuscript, however, has not yet been sent in.—Ed,
as every person of right feeling and judgment must desire, the provisions
required are so numerous, and have to seek their principles in so many
departments of knowledge, that these, the sanitary branches, would alone
occupy many minds and many days in a full discussion of them.

The military branch of these subjects it falls, of course, to members of
the profession of arms to discuss. But there can be no real military effi-
ciency in these departments without a corresponding sanitary efficiency.
How vast the importance of the latter is we have been taught, not so much
by its presence, alas! as by its too frequent absence hitherto in the British
and Indo-British armies. In the field more especially before us—India—
we have been taught what the comparative importance of the sanitary
question is, in the fact that, with contingencies far more favourable than
we had a right to calculate upon during the perils of the last two years,
the assaults of the enemy have, in their effects, scarcely exceeded a tithe
of those produced by climate; which has been also the chief destroyer even
of the wounded. And in many a march where not one man has been
wounded, numbers have fallen under sun-stroke. In what was called the
defeat of a body of Her Majesty's 35th, at Arrali, the following authentic
list of the casualties will show, that it was no defeat by man, but by the
sun—a panic, not from the startling surprise itself, but from the action of
the sun upon men's brains—upon those who died and those who survived:

Detachment of Her Majesty's 35th.—Officers.—Killed, 1; died from apoplexy, 2.
Men.—Killed, 8; wounded (but died from apoplexy), 10; died from apoplexy, 84;
total, 102 men and 3 officers.
Naval Brigade.—Killed, 5; wounded (8 died from apoplexy) 9; died from apoplexy,
5; total, 19.
Artillery.—Killed, 3; died of apoplexy, 1; total, 4.
Ratitary's Sikhs.—Killed, 7; wounded, 7; officers wounded (Captain Waller), 1;
total, 15.
Grand total, killed, wounded, and missing, 143.

Here were, in the 35th Regiment, 96 deaths by the sun, 10 of which
were cases of wounds rendered fatal by solar apoplexy; and only 9 killed
in conflict. What then must have been the cerebral condition of the sur-
vivors, and what havoc in their other vitals has not since resulted!

Of the troops which under Sir Henry Havelock so nobly turned the tide
of rebel progress, the great majority have perished by the climate; and
mainly through the sun's direct and indirect action.

I have seen letters stating that soldiers, though wearied by exertion and
exhausted by heat, have oftentimes not dared to lie down at night to rest,
lest the sun's influence, which had been withstood while they were in an
erect position, should only have been postponed until the horizontal position
and diminished vitality of sleep, by favouring the induction of apoplexy
(sanguineous in some, and nervous in others), should cause them to be
overtaken by death while they were seeking refreshment in sleep. Such a
spectacle as that of wearied comrades snoring into death might well appal
the stoutest hearts!

But this direct sun-stroke by day and deferred sun-stroke at night,
though the most appalling, are not the most extensive effects of the sun.
There are thousands who escape it, but whose constitutions become quickly
ruined by the sun; who are by it disabled to survive any but slight wounds
and operations, and who are by it rendered, long afterwards, obnoxious to the action of every form of malaria prevalent, chiefly through the exhaustion of the skin; for, as I have elsewhere taken occasion to remark, it may be received as a pathological maxim—that the skin's debility is malaria's opportunity.

It has also to be borne in mind, that it is not so much atmospheric heat, but mainly the solar ray, which has to be dreaded in the field. Gradually injurious as the former is, and not to be trifled with when avoidable, it can be borne by most persons of any vigour for a long time, without destructive consequences. The Parliamentary Reports on bleach-works in England show that even women and children endure for years the cruel heat of stoved rooms exceeding most atmospheric heat in India.

Disastrous as has been the decadence of hundreds of fine men in the prime of life, the casualties from climate would have been manifold greater, had not the Sikh and Punjabees, through the consummate ability of the rulers in the Punjaub, been brought into that position between the British soldier and the sun of India deserted by the Hindoo sepoy, and performed many a duty by day which would have been destructive to our countrymen, equipped as they were; and had not also the Commander-in-chief manifested his excellent judgment and feeling in forbidding to the utmost all unavoidable exposure of them, even though the Sikhs should vaunt themselves upon their ancillary feats in the sun. The intervention of the auxiliary Sikh, and the judgment to employ him to the utmost in shielding the European, can be rightly viewed only as a Providential arrangement for preventing the consummation of the revolutionary work; for, otherwise, a mortality of British troops would have been witnessed which could scarcely fail to have invited a more general insurrection, and would certainly, had the conflict been prolonged, have soon exhausted the British forces in the country, and the military resources here for recruiting them.

Since calamities from solar influence have been witnessed on a grand scale, once at least in every decade of our hundred years of Indian experience, and in a great though minor degree in peace throughout the whole of that time, it might be supposed, and it has been by many, that this deplorable destruction of British life and health is an unavoidable contingency of our retention of a great tropical dependency. Some, on the other hand, contrasting the destructive effects of the sun upon troops thrown into India in their European clothing, with the greater protective power of an Asiatic costume, have placed too implicit a confidence in the turban, "sola" pith hat, and white tunic.

The fact, long established in physics, and very valuable under certain circumstances, that such white surfaces repel far more heat than do darker ones, has also tended to confirm this reliance in them, and especially in the "sola" hat, on account of its substance being also a slow conductor of heat.

Now these important properties will not alone avail. It is notorious that under a white cotton head-dress many men on the line of march have dropped down in apoplexy, and far more have had their constitutions ruined by the sun. I am informed that officers in Burmah were sun-struck while wearing the "sola topee."

I never met with the man who, though often with fancied, could with
real impunity expose himself day by day and throughout the day, relying
ordinary sola-hat, unaided by at least an occasional use also of a

would not be otherwise. The outer layer of tents, even when new
dazzling whiteness, and though lofty, and having below it many
cotton cloth in the two "flies," cannot, unless under the further
shade of trees, save the inmates from needing often a wetted turban, or
being driven under the table for further protection.

Moreover, not only do rain, dust, and the smoke of war soon destroy
that purity of colour requisite to give much reflective value to whiteness,
but, unlike a properly directed metallic face, white reflects solar as well as
diffused light in nearly all directions, and must therefore, when spread
over an army of men, become trying to the eyesight. But I do entirely
believe, and the further my inquiries and experiments have carried me,
the stronger grows the conviction, that there is not in the nature of the
case anything to prevent our holding India securely without causing
annually, as well as periodically, a moral depravation and bodily destruc-
tion of so many thousands of our fellow-countrymen in the ranks.

Our hundred years of apparent experience to the contrary can be allowed
to weigh nothing, when it is borne in mind that the physiological and
sanitary branches of military organization in India have never been author-
itively represented in the "Council Chamber;" whereas the fields of
science these branches spread over, are so various, and the application of
principles of the greatest importance, is often so difficult, that a due pro-
portion of the authoritative body should manifestly be composed of minds
severally devoted to the cultivation of the different fields of such science.

That proportion will not be a small one when, if ever, men in responsible
power shall duly consider that there are few, if any, military questions
with which these several branches of physical and sanitary science are not
in some way concerned, and a vast number in which they are wholly or
mainly concerned. It is of little use that such knowledge should be
available when called for. It must exercise a prompt and authoritative
influence in the decision of every question in which these branches of
knowledge had a part. Of this we may rest assured, that on every
class upon which such influence should be rightly exerted, the military
object itself would be eventually promoted.

Even on such a question as the right suspending and poising of the
traps a soldier has to carry, ought those who had studied his bony struc-
ture, and the position, direction, comparative strength, and uses of his
muscles, to be carefully excluded from the decision?

What physiologist of any genius and independent thought, if placed in
responsible authority, could have ever committed the error of distressing
the soldier with a stiff neck-stock, disturbing the easy play and the
tension-balance of the neck-muscles, and exercising a dangerous and
stupifying compression of the jugular veins, or (by tight buttoning and
girting) of squeezing out half the resident air of his lungs, and impeding
the free action of the intercostal muscles and the diaphragm: as if the
object were to enfeeble the whole system by restraining the purification
and oxygenation of the life-blood? What council which, comprised with
physiologists, men also devoted severally to natural philosophy, to experi-
mental and to mechanical science, could have devised or consented to the adoption of such head-dresses as the "shako," the bearskin cap, and the foraging cap? Is it to be wondered at, that whenever an army takes the field under at all trying circumstances the same disasters recur again and again, when we find the office, not only of manufacturing, but of contriving also, to be commonly handed over to those whose respectability in their several trades, however high, offers no guarantee of a scientific qualification for the task, but is almost incompatible with it—while we find persons who have not devoted a single year, not, perhaps, a single month, to the cultivation of the many branches of natural and experimental science involved in the questions before us, undertaking tasks upon a right fulfilment of which, hangs the lives of thousands?

Of this I am very certain, that the deeper the insight any man shall acquire into the principles involved, and the provisions requisite for giving to each principle a play proportional to its importance, the deeper will be his sense of responsibility in the undertaking, and the greater his desire that it should be shared by other minds; each taking in hand his especial part, and submitting his views to the collective judgment of the rest.

Thus, with respect to the plans I am about to submit to you, I should be sorry indeed to appear to arrogate for them perfection. It was not till the eleventh hour, when the mutiny had occurred, that, unable of course to foresee the heaven-sent Sikh standing between our countrymen and the sun, I ventured to express to those in authority the conviction, on the one hand, that without more suitable dress for the soldiery, little else than extermination awaited them, and, on the other, that such were the resources offered by natural science that sun-stroke ought never to befall men in fair health. Under this impulse I left at the India House, two years ago, certain helmets, hastily constructed, of those redoubtable proportions which had afforded me effective protection during seven years of trying exposure—and to which I naturally clung, though they were doubtless too cumbersome for military use. By a mistake those helmets were sent out to India, with copies of my work on the British Army in India, which the late Court did me the honour themselves to forward, contrary to the understanding upon which the helmets were left at the India House.

While attempting, in a single discourse, to submit to your judgment certain results of my own experience and experiments, in proportion as I shall be compelled to hurry over the details, do I feel the necessity to be the greater that some remarks should be premised upon the leading principles they involve.

Time permits me to refer to little more than a few points relating to the sun's action both on the living man and on inanimate matter, available for his protection from its rays.

With respect to the action of the sun upon the living body, I have already offered a few remarks. In a work published the year before last, of which a copy was I believe sent to most persons in authority, it was my endeavour to throw some fresh light upon the subject, and at the same time to treat it in a popular and, as I hoped, an impressive manner. I would here only invite attention briefly to the consideration that, while the brain is the part most sensitive to the influence of the sun, it is not only that organ which, with the spine, gives action to all the vital and animal
functions, but it is the seat of the mind also. It is the seat of a man's courage or nervous timidity, of the elevation or depression of his spirits, of his contentment or disaffection. When we see in a marching column this great organ, so incomprehensible in the variety of its marvellous functions, sun-struck in every degree, from a slight headache up to snorting apoplexy, and when we do actually witness the induction of mania in certain instances, and when we further consider how infectious are mental impressions, under any common influence, we must, I think, regard it as surprising, and nothing less than beneficently providential, that whole bodies of men have not as yet been seized with frenzy; or that their mental functions have not been at least so far disturbed, that panic, or the inveterate desire to return to one's native country termed nostalgia, or a sullen disaffection, have not, one or all of them, been induced.

Let it not be idly assumed, because such results of climatic influence may not as yet have become epidemic, that they never can. If report be correct, after a certain detachment had lost, it is said, three-fourths of its men in one day by the sun, something like panic was manifested in a body succeeding to the duty.

I proceed to say a few words on the reception given to the sun's rays by certain inanimate substances, especially by their surfaces.

The importance of this question will appear in all the stronger light when we bear in mind that, excepting when a man suffers from having exposed himself uncovered to the sun, we speak incorrectly in saying, "he is sun-struck." When he is wearing a hat, or is under a roof, as of an opaque tent or house, he is hat-struck, tent-struck, or house-struck, but not sun-struck. The sun only strikes these intervening matters. Its rays are entirely arrested by them, and it is they which transmit them to their under surface, and then impart them to the head; by direct conduction where they touch it, by radiation to it where they do not, and also by heating the intervening air.

Many a man is struck dead by the radiating power of the interior surface of his hat.

Absolute contact, or near approximation of the sun-struck matter to the head or body, being the worst condition possible, it is desirable that around the sides, as well as the top of the head, in the case of the head-dress, and of the whole body, in the case of tents, as free a space should be given as is admissible, for air to blow copiously by, that it may both ventilate the living surfaces and (by convection) carry off into the atmosphere heat from the perniciously radiating surfaces around them. Whether it be a tent, or house, it must have free ways for air both to come in and pass out, but at the same time the current should be under thorough control. Thus much briefly for the universal importance of ventilation and convection.

With respect to the processes by which solar heat is received and set in motion by terrestrial matter, namely by radiation, reflection, conduction, and convection, there are peculiarities in their application to the cases before us, which require that we should seek instruction by experimental inquiry, differing in certain respects from any which have been recorded, so far as I am aware. Space compels me to presume that my hearers are
acquainted with the scientific truths already established on the subject, and to confine my remarks to a few results of my own inquiry.

I must presume that it will be in the recollection of my hearers, that nearly in proportion as the surfaces of opaque matter are dense, smooth, and bright, especially as they are metallic, will they prove both least willing to receive heat projected upon them from bodies not in contact with them, and least willing also to project, or radiate, heat from themselves, while they are most ready to receive and transmit heat from bodies in actual contact with them, i.e. by conduction; and by converse, in proportion as surfaces of matter are porous and rough, and also as they are of dark colour (especially fibrous and organised matter, such as cloth), do they both most willingly absorb heat radiated upon them, and most willingly also part with it by radiation, while they are slow to receive or transmit heat by conduction. Furthermore, that these opposite properties of matter in relation to radiation appear to lie in the very surface itself. The thinnest film of metal overlying any matter will greatly restrain the passage of heat by way of radiation.

The plans I have to put before you are based chiefly upon observations made in India, on the action of the sun, and upon experience in different means for warding it off; and partly upon more recent experiments with thermometers variously coated; and with others inclosed in hollow cylinders and prisms. The thermometers employed had most of them cylindrical bulbs. Desiring to obtain a mercurial thermometer of increased surface and sensitiveness, by greatly increasing the proportion of the surface to the mass of metal, so that it might be possible to observe momentarily the relative absorption of the solar heat by clouds of different density, in their transit, it occurred to me, if two hemispheres of slightly different radii were placed, the smaller within the larger, and could be sealed together round the edge, and have a tube connected to them communicating with the concave space between the spherical sections, that, if this space were filled with mercury, a thermometer of both great surface and of great sensitiveness would be obtained; that its two spherical surfaces, even the concave one, would, though it should be 1½ inch across, be able to sustain the atmospheric pressure upon the vacuum within, which flat sides could not, for an instant; that the expansion and contraction of the one surface might so closely correspond with that of the other, that a uniform rate might be obtained which could be easily determined, and would not disturb the indications of the mercury, though each apparent expansion of it might be in a small degree lessened; and, lastly, that for certain observations a spacious concave surface would offer peculiar advantages.

On mentioning my wish to Mr. Zambra, of the house of Negretti and Zambra, he stated that in blowing thermometer bulbs he had occasionally, I believe by some accident, sucked one hemisphere of the bulb into the hollow of the other, and, though he had never turned it to account, he thought he could produce such an instrument as I was seeking. The one before us, fig. 1, is the result, and I think, for a first attempt, shows great skill in the maker. A A is a transverse mid-section of a hollow hemisphere of glass, with an ordinary stem B B rising up from its edge. The dotted curves C C C complete the form of the bulb, as seen on its concave side. Though the bore of the tube is too large, and it is other-
wise not perfect, it promises well. Such a thermometer is well adapted
for solar observations, whether the concave or convex surface be employed.
When the latter is blackened, and presents its large surface to the sun, the
concave back can be easily shielded from the action of wind and from loss
of heat by its own radiation by a drum-head of gilt or aluminium paper
stretched across it.

Next to a thermometer insulated in a vacuum, this, I think, promises to
be the most suitable instrument.

My observations have generally been made with half a dozen or more
thermometers at once, some with the bulb in contact with the covering
medium, with the bulb insulated in single cylinders or quadrangular
prisms of three different diameters; some in two cylinders, one within the
other, and some in three concentric cylinders—the cylinders themselves
being of various materials, and variously coated, and being sometimes
thickly wrapped round with different substances. The current of the air
up the cylinders was sometimes increased by elongating them with a glass
tube acting as a chimney. At other times the current was shut off by
card valves, the air stagnating within them as in a common "shako" or
helmet, or in the pyramid of a tent. Desirous of trying the repellent
virtues of the new metal—aluminium, and having heard that Mr. Marshall,
a manufacturer of leaf metal of much ingenuity and spirit, had produced
specimens of aluminium beaten into leaf, I applied to him, and found him
much interested in my proposal that it should be introduced as a coating
for the surfaces of hats. At no little trouble—the manufacture being new—he prepared for me some books of aluminium leaf. The present is,
I believe, the first employment of this metal in the form of leaf, and it
promises to be of much utility. I find it to possess great reflecting
power, though the experiments have not been continued long enough to
declare its virtues as compared with gold leaf. It has apparently little
liability to become tarnished. The interior of this pattern helmet is lined
with leaf aluminium. I find it to form an excellent article also in the form
of aluminium paper. Both aluminium and tin, in the form of leaf or
bronze, could, I am satisfied from trial, be united to a smooth calico or
linen surface, by means of a flexible cement, prepared from gutta-percha,
india-rubber, or other hydro-carbons. I find on trial both india-rubber
and gutta-percha promise to answer the purpose, and to have the great
advantage of giving much flexibility to a metallic cloth.

The chief obstacle to their employment might prove to be the fusibility
of the cement, but this might probably be remedied, or some other cement
employed less brittle than gold size. The common japan used for patent
leather might answer the purpose of a cement for fixing the bronze.

I find, then, in the first place, that the power which a single surface of
these metals (though a mere film in thickness, and of but moderate smooth-
ness and brightness) possesses of reflecting luminous heat, will enable it to
arrest the entrance of solar heat more than any quantity and bulk of fibrous
matter like felt or cloth, which could be employed in a head-dress or in a
tent, and which acts only on the principle of slow conduction, erroneously
termed non-conduction. Of so little comparative avail are such fibrous
matters in arresting the sun's impinging heat, that they can scarcely be
called even slow conductors.
Experiments with thermometers, in which the screening substance is in contact with the thermometer, have, during the last century, been repeatedly made and published. With their general results, the trials I have made of that character have duly accorded; as likewise appear to have done the recent valuable observations by a French physician, Doctor Soulier, upon the different wave fabrics employed in soldiers' dress; but I have thought it also of much practical importance, as well as of scientific interest, to determine, by gradually thickening the screening substance, what, as a slow conductor, would be the behaviour of this increased mass towards heat which was being accumulated in its willingly receptive surface, and was being pressed inwards for transmission through the mass by the force of the solar ray behind. I find, as I have abundantly observed in India, that a slow conductor of such solar heat is but a poor principle to rely on alone. Hence it is, that no thickness of masonry roof, and scarcely any reasonable thickness of thatch, will, without great loftiness of rooms, suffice to keep out solar heat at all effectually.

We may next consider experiments designed to correspond in principle with a well-ventilated hat or tent, where a current of air flows between the screening substance and the body to be screened. If a thermometer with a blackened cylindrical bulb of one quarter of an inch in diameter be insolated in the centre of a cylinder five inches long, open at top and bottom, and of half an inch diameter, so that there is about one-eighth of an inch space all round between the thermometer and the cylinder, for a current of air, it will be found that if that cylinder shall consist of only thin paper, coated outwardly with gold leaf or aluminium leaf, or even with tin bronze, it will, in a still atmosphere, arrest from five-eighths to seven-eighths of the sun's direct rays.

If the cylinder be also coated on its inside with any such leaf metal, it will have the retarding effect improved by about a sixth or eighth through the aid of the slow radiation of the interior metallic surface.

If the cylinder be formed of stout cotton cloth of close texture, and having a smooth and purely white surface, such as white satin jean, it also will possess great reflecting power, though many degrees inferior to the metallic face; but a slight discolouration of the surface rapidly diminishes the effect. If it be soiled, as in practice it soon must by dust, &c. to a buff or light brown, it will be found to lose half its virtue. Moreover, although a metallic surface does certainly throw off the sun's rays with an intense brilliancy at the angle of reflection, if the surface be straight in a vertical direction, like the cylinder of a common hat, or the wall of a house or tent, or if it be a horizontal plain above the level of the eye, like the top of a hat or flat roof, such brilliant rays from it cannot be thrown into the eyes of neighbours on the same or a lower level, but will be reflected to the ground from the vertical sides, and to the heavens from the horizontal.

I find a flat sheet of brilliant metal hung vertically out of doors to be very little visible, even at a few paces' distance, especially with a cloudless sky, in whatever position the sun may be, excepting, of course, for a few minutes at sunrise or sunset, when its brilliancy does indeed attest its reflective virtue; but a white surface of equal size is visible and glaring in most positions, reflecting both solar and diffused light in various directions.
Thus we see that, by simply providing that the surfaces shone upon shall not lie in certain planes of reflection, a metallic face, while much more effective than a white one, becomes actually less visible than almost any others.

Again—If the small cylinder around the thermometer be made of brown flock or felt, its power of averting rays is very small; a blackened thermometer bulb, placed centrally within it, will rise to within a few degrees of what a black bulb does when exposed to the sun and sheltered from wind. When cylinders of a darker colour than an earthy-brown are used, the resisting power decreases, but not very materially; a rough brown surface is so penetrable by rays, that it leaves but little room for increase of absorption by darker surfaces.

Neither do we gain much by increasing the thickness of a material and trusting to a slow conduction of heat alone. If we close the bottom of the cylinder and roll it up in a sheet of the thin brown cork of which cork hats are made, so as to envelope it with a dozen layers of cork, far more heat will penetrate in ten minutes through the whole mass, than in as many hours through an open cylinder made of thin paper merely, and faced inside and outside with tin bronze, like the paper used by tea-dealers. In fact, in less than half-an-hour, the thermometer, under the many layers of cork, will rise to within three-fourths of what it will when its blackened bulb is exposed to the full power of the sun; while the thermometer within the metal cylinder will not rise one-third as much.

We have here exemplified the dangerous character of non-reflecting and poorly-ventilated hats.

Even the sola topze—a hat made of that best of slow conductors the pith "sola," which possesses also a smooth white surface—will not protect all constitutions from even that extremity of solar mischief, sun-stroke.

I am informed that officers in Burmah frequently fell under the sun while wearing large "sola" hats. I have known half-castes themselves, (in one instance a very strong man,) who could not, without suffering, expose themselves during a whole day with any ordinary sola hat, unless sheltered with a chattah as well. Where a person is mounted on horseback, elevation from the ground, but especially the currents of wind on the hat, created by riding, will materially aid the defensive power of such hats; but it is only particular constitutions which can rely on them with any security.

Neither can the slow conduct of the most massive turban, offer, apart from its whiteness, any considerable security. Gradually conducting inwards the solar heat, and detaining the animal heat, though it may ward off the extremity of sun-stroke, and answer for a limited exposure, morning and evening, it cannot fail of permitting a rapid constitutional injury to be produced by much exposure to a mid-day sun.

If we place the bright metal cylinder inside of another cylinder of cork or felt, in substance about twice the thickness of card, and larger than the contained cylinder by one-eighth of an inch all round, for the free ascent of air, the protective effect of the bright cylinder will be actually damaged by the outer cork or felt one, and very materially. The thermometer within the inner metal cylinder will rise, and rapidly, much
higher under this double screen (although the air has a free play between the two cylinders) than if the outer cylinder be removed, and the unaided metallic surface of the inner cylinder is left free to repel the direct rays of the sun. If, in lieu of the inner metallised cylinder, there be placed within the outer felt cylinder a small one composed, like it, of brown felt, the heat-arresting effect of the double felts will be less than of an outer felt and inner metal cylinder. It is much better, however, to have a double layer of any fibrous material, as cloth or felt, with a free way of air between them, than to have the same mass united in a single body. These experiments also show that, in employing hats with double shells or crowns, there is sufficient virtue in interior metallic surfaces to render it expedient that the inner face of the outer shell, and both faces of the inner shell, should be coated with either tin or aluminium, bronze or gold leaf; the first answers well, and costs almost nothing in the form of tin paper. But, as already remarked, nothing can compensate for the absence of a powerfully reflecting exterior surface, facing the sun—one of bright metal, where it can be employed, or a purely white and smooth cloth, or enamel, where metal cannot be used.

In these experiments with large inclosing cylinders and prisms, it is here proper to note the fact, that there is, in the size of a hat, a limit beyond which any gain from increased freedom of ventilation would be overruled by an increased interception of the solar rays by the enlarged surface, and inward transmission and concentration of much of their heat. In no hat is this limit likely to be reached; but placing a large concave over the head becomes a serious question in the case of umbrellas used as parasols, of parasols themselves, and of chattals. In the roofs of small boats, and of tents, it is more serious still, owing to the air within them not circulating away freely as with a parasol.

In the experiments with thermometers I was led to try the square prism as well as the cylinder, on account of the tendency of the latter to concentrate the radiations from their inner surface. The fact referred to is this, that while, owing to the sun's great distance, the rays which reach our earth arrive in virtually parallel lines of vibration, if they fall upon a convex surface, especially on a hemisphere like an umbrella, such of the rays as are transmitted to the concave side and radiated from it, are thrown off in rays having a mean direction perpendicular to the concave, and are accumulated, or more thick set, in the space inclosed within the concave surface. This is a serious matter when a person's head is anywhere within that space, and there is not a free flow of air over the inner and outer surfaces of the hemisphere to carry off most of the heat, before it is radiated and concentrated upon the head. Hence, our umbrellas and parasols are very faulty in their form as protectors from the sun, and should always be held at a sufficient distance from the head, that it may be below the conflux of the rays. Much the best form for a parasol would be that of the common Indian chattah used by the poor; namely, a flat circle turned over at the edges. Many a headache would be escaped by the fair population if such a form could but take its well-deserved place as a fashion.

Having referred to but a few only of the experimental data, and touched them too lightly for any clear explanations, I proceed to describe constructions in which, while the teaching of such experiments has been duly
respected, the chief data have been taken from a personal experience of several years in India; not an experience of mere passivity, but of active trial.

Under the head of dress I can do little more, without intruding upon the time due to my other subjects,* than speak of head-dress, and must hasten over the details of it; omitting, indeed, many of them. Permit me to premise, what it is of much importance should be impressed upon the mind, that, while all that is believed to be desirable with respect to weight, bulk, form, &c. is here advocated, it does not follow that the principles themselves should be considered inseparable from such proportions. If we adhere to the principles, they will enable us to carry our restrictions in size and weight, without deadly consequences, further than we can if we rashly reject the principles.

Furthermore, each principle, and the contrivance for giving effect to it, stands so far independent of the rest, that the eye of disfavour cast upon any one, ought not therefore to be turned upon the others. In short, attention is invited to the principles chiefly, and next, to the plans for giving effect to them, rather than to the material accidents under which they are offered to notice.

To employ a hat with two crowns, or shells, having a spacious passage for air between them to carry off, by convection, heat which had penetrated the outer crown, occurred to me between thirty and forty years ago. The first hat I made was helmet-shaped, not unlike the pattern, fig. 2, excepting that it had not the coronet ventilator. With this I travelled over the Himalayas, most of the time on foot, for six months. The next was shaped like a common broad-brimmed hat, and made of the sola pith. The attention of indigo planters and others was invited to it, and the use of such hats has been gradually extended in India. Within a few years a patent has been taken out for the application of this principle by a manufacturer in England. Although the principle is seriously compromised, from the manner in which it is carried out in the patent hat, it is said to be superior to most others in use in India.

To be effective, every tropical hat which has not a metallic or purely white exterior, must, I conceive, have such a double crown, with a free space between the crowns, and a very free outlet at top as well as inlet below, for a current of air which can only thus really act as one of convection, carrying off heat from the outer shell into the atmosphere; otherwise the heated current, if sluggish through the pitifulness of the space and of the outlet at top, will deposit much of the heat upon the inner crown; a fact I have abundantly established by trial.

Also, between the inner crown and the head, there must be ample freedom for the passage up of a far more important current still, namely, one that shall have access to and ventilate the head, as well as sweep away from the inner crown solar heat penetrating it from without. At the same time, this ventilating current must be under absolute control. If, similar to a common hat, the head-dress be given vertical sides and a flat top, a reflecting metallic exterior will be admissible, and a single shell or crown may suffice, provided there be an ample current of ventilation within it;

* The subjects of tents and barracks for British troops in tropical climates, especially in India, were treated of in a subsequent paper.—En.
but the additional security of an interior shell is desirable, where the bulk is not objected to.

I proceed to describe, first, a helmet, spheroidal in form, and not metallic at the surface. Of such a helmet I here show a pattern, seen in section in fig. 2.

The first point to be considered is the question of weight; one upon which much has been said, and misconception, lamentable in its consequences, has prevailed. If the head be placed in a box, air-tight, or nearly so, and having a heat-absorbing exterior surface, like a common shako, and pressing also with rigidity and painful constriction round the head, a little marching under a hot sun will cause such a head-dress to feel intolerably weighty, even if it could be made so much lighter than air, that, if it were to escape from the head, it would float away into the heavens.

This sense of weight is produced by solar heat pressing rapidly in and radiated down by the hat, falling like a load upon a head which is oppressed at the same time by the confinement of its own animal heat and perspiration.* Hence in Military as well as Civil life, the real causes of this false impression of heaviness being overlooked, there has been an anxious endeavours to bring the shako down to the least possible weight, every ounce saved being thought a great gain. So likewise we see gentlemen's cork hats in shop windows boastingly poised against, I believe, 4 ounces in a scale. Now I have myself had to remove such a hat from my head oftener in a hot summer's day here, and been more distressed by it than by a helmet (the first of my attempts after a rational construction) when tramping in it by hill sides and even through hot valleys of the Himalayas, although it must have weighed nearly a pound and a half. In short, while the endeavour has been anxiously made to lessen the weight of the shako, if by only an ounce, any fish or fruit-woman in England would be happy for a good day's hire to walk a march with three or four dozen shakos in her basket on her head, if room could be found for them, and any Hindoo milkwoman in India would gladly take half or three-fourths of that number in lieu of the load of milk she will carry on her head from the marshes many a mile into a distant town; but provided always that neither of the women should be required to wear one of the shakos herself. That one shako would assuredly distress her more than all the rest. The fact is, there is no part of the human body that can be more readily exercised in such endurance it surpasses the back and almost equals the shoulders. In all ages and countries it has been instinctively chosen as the seat for loads, especially for loads carried great distances.

While therefore in the head-dress, as in the rifle and everything else a soldier has to carry, all superfluous weight ought undoubtedly to be avoided; while, instead of any such clumsy accumulation of matter, opposed

* It is notorious that, even in Europe, the distress caused by their shakos has led soldiers on the line of march, as in the Crimean war, to throw them aside in large numbers and to trust to their pitiful foraging caps—a result due to their suffocative structure and hard constriction of the brows and temples, but erroneously attributed to their weight (utterly trifling) of a pound. The late Sir Charles Napier, who proposed to relieve his men, when jaded by their knapsacks, by making them carry them on their heads, would have readily discerned of how small importance is any weight and bulk in a helmet necessary for effective protection.—J. J.
to all science, as is a turban, saving its whiteness, the repulsion of solar heat and the dissipation of animal heat ought to be committed to the smallest weight and bulk of matter and the choicest form by which these ends can be thoroughly effected—while this is unquestioned, yet no error can be greater than to put restraint upon any such weight, bulk, and form as are required for perfect efficiency.

Next, with respect to bulk, the utmost size which could be needed would not, if the form be well devised, cause one-half of the uneasiness in a high wind which is produced by a common hat. In a hat, the centre of force of the wind is much above the centre of pressure on the brow, and produces a wrenching action which tends to displace the hat and to render necessary a painful tightness in its fitting, and also, for keeping the hat on, a wearying constriction of the muscles of the brow and head.

It is this leverage which is most trying. In the case of the high bear-skin cap it must have consumed a large part of the effective strength of any soldier marching against a strong breeze. But, if all excess of height in a hat above what is necessary be avoided, and if the breadth of the upper part of a hat or helmet be contracted as far as efficiency will permit, and if the brim have a sufficient breadth and downward bend given to it for protecting the face and sides of the head, it will be found that the surface presented to the air by the brim, which is below the centre of pressure, will equal that presented by the portion of the crown above the centre of pressure. The force of wind then on the brim tending to tilt the hat downwards will balance the leverage of the wind acting on the crown tending to tilt it upwards. In short, the centre of force will correspond with the centre of pressure.

The question of size then is closely allied to that of form. While the hat is on the head, any necessary size will be found to offer little inconvenience provided the form be such that the centres of pressure of the wind upon it, and of it against the head, shall correspond. This pattern helmet is formed of such proportions as carry out this principle.

With respect to form, none will be found quite equal, so far as the action of wind is concerned, to that of a spheroidal or elliptic helmet, having a broad declining brim; and I take leave, on the authority of some of the choicest architectural forms—domes surmounted by a circular gallery, to think that none would wear a more commanding and martial appearance than the elliptic form of a helmet surmounted by a circular coronet, as soon as the eye became familiarized with it. To remove the jockey-cap ugliness of a bald helmet, the ancients surmounted the helmet with the Minerva crest, handsome enough to the eye when edged with richly-projecting mouldings of rigid metal, but exhibiting little sign of utility—the true standard of taste in every manly business. When, however, the Minerva crest is imitated in dull rounded impossibly felt or leather, unless necessity in use can be shown for its presence (for then indeed the eye should learn to accept anything), I must think that Phidias, who sculptured, or the artist who designed the ancient crest, would, if now present, implore that helmets might be left bald rather than be surmounted by sausages in lieu of crests. At all events a hollow crest, with a mouth opening forwards and with the passage sloping down backwards, forms a very unsuitable channel for the exit of an internal ventilating current, as will be explained in the sequel.
In raising this question of taste, I do so with no other object than that of bringing every influence available in support of a ventilating provision which I believe to be most desirable, nay, almost essential for any tropical hat or helmet which is to possess thorough efficiency. I would on no account appear so to trifle with a question of life and death like the present, as, like a man-milliner, to dwell on points of appearance for their own sake, points which every thinking and feeling man must view as altogether insignificant, while fellow-members of his own national family are liable to be called upon devotedly and loyally to expose themselves at a moment's command, and, as a consequence, if fashion and not efficiency in dress be the order of the day, to be one after another dropping down in the apoplectic snort, or one here, and another there, sleeping into death at night, and all of them to be laying in, more or less, the seeds of vital disease!

Whilst, however, a crown of a helmet-form, having a broad inclined brim, is the best with reference to the action of wind, it does not so well admit the employment of a bright reflecting surface for the repulsion of the solar rays, as will be presently considered.

We may now proceed to consider the constructive details for giving effect to the physical provisions requisite for a tropical hat.

Commencing from within, I would beg an especial attention to that part of the hat which applies itself to the head. It should, I conceive, consist of a strong draw-cap, \( h h \), fig. 2, resting on the head to carry the weight, and attached around its lower edge to a broad band \( H H \), encircling the brow and sides of the head. Both the cap and the band should be made of open and strong fabrics, and be variable in their dimensions. For the cap, I have employed an open made canvas, and for the band an open-made horsehair cloth, as a fabric cool and always clean. The cap and band are of open texture, that the animal exhalations and animal heat may have free exit through them, and that air may freely permeate them to support the respiration of the skin as well as its perspiration. They are strong: the cap, that it may carry the weight of the hat on the head; and the band, that it may keep the hat in rigid lateral security by firmly encircling the head when such security is needful. Lastly, they are variable in dimensions; the draw-cap, that the hat may be so poised as to have its centre of gravity placed well below the centre of support about the head. When this is the case, there will be no necessity excepting on especial occasions, as during action, or in a high wind, for the head to be at all firmly encircled by the band; and even a firmer compression than can ever be needed will produce, owing to the band's pliability adapting it comfortably to the contour of the head, no painful constriction, as is the case with a rigid hat.

The band itself must therefore be variable in its dimensions; not only that the same hat may fit with equal comfort a variety of heads, so that two or three sizes may suit a whole army perfectly, but also that the same wearer may vary the tightness at his pleasure. Ordinarily, in a hot march he would wear the head-band quite loose, but at a moment's notice he should, without removing his hat, be able to make it engirt his head so well as to surpass, in the security of the hold, and without uneasiness, the most painfully constricting hat. This immediate command over the band is effected by means of a strong double-ended cord, \( T T \), winding over a
thumb-peg, $V$, exterior to the hat at the back; which peg revolves over a circular ratchet, over the inclines of which it travels easily one way for winding tight, but is detained from revolving back by the upright edges of the ratchet. By drawing out the peg a sixth of an inch, it clears the ridges of the ratchet, and is turned back for loosening the head-band within the hat.

The importance of such a provision cannot, I believe, be exaggerated. Whatever may be the material, form, or construction of the body of the hat, a porous draw-cap, resting on the head to carry the weight, and a porous and flexible band encircling the head, and momentarily variable in its dimensions, ought to be viewed as a sine quâ non for a soldier's head-dress, more especially in the tropics. It is painful to see a serjeant hammering with his palm, that they may fit securely when engaged with the enemy, shoves of one rigid, oval form, upon heads of infinite variety in their contour, and to reflect that during ninety-nine in every hundred hours of their use, no such tightness is necessary if the hat be rightly poised on the head with its centre of gravity low, and there be a loose chin-strap to guard against accidental displacement. With the brow relieved of all constriction, a man can walk without weariness a distance which would utterly exhaust him with a constricted brow and suffocated head.

Exterior to the porous head-band there should be a free space, $ff$, fig. 2, entirely around the head, of from three-eighths to half of an inch wide, both to afford room for the free expansion of the band, and, more especially, for the free passage of a copious current of ventilating air.

Exterior to this air-passage is the shell or crown, $EE$, of the hat (the inner one, where there are two shells). This crown, though larger than the head by three-eighths or half an inch all round, need not rise above it more than one or two inches, and it should have a central aperture at top an inch and a half in diameter to afford to the ventilating current as free a passage for its exit, as that around the head for its entrance.

A free entrance round the head is of little use unless the exit at top be also free, for the ventilating current has various duties to perform, for which it becomes rapidly disqualified by any detention. It ought to cool the head by evaporating away the perspiration, and should, therefore, permit but little of it to assume the form of liquid sweat. It has to feed the pores of the head with oxygenous air, for the skin respires as well as perspires, and it has to sweep away by conduction from the interior surface of the hat such solar heat as has penetrated through it from without,—which heat, if it be not thus carried away by this current, will to a certainty be radiated by the hat upon the head of the wearer, especially if the interior of the hat have not a metallic face. The thinnest coating of leaf gold, aluminium, or even leaf tin, weighing but a few grains, will be found to have some decided effect in checking the radiation inwards, and allowing the ventilating current time to carry off such heat by conduction. This metallic face, also, will not grow soiled by dust or sweat, which can be readily wiped or washed off it—a point of importance in regard to cleanliness and sweetness. The substance itself of this shell or crown should consist of matter which is a slow conductor of heat; or, if there is no shell exterior to it, it ought, I think, to be lined inwardly with wadding or the pith of the Indian reed sola, in order to retard in some degree the conduct
Improvements in Helmets, etc. for

Inwards of heat, which lining would of course have the coating of leaf metal over its inner face. The inner shell of this pattern helmet is coated on its outer surface with cork one-eighth of an inch thick, and that faced with leaf metal. Before proceeding further outwards, we have to look to a point of especial importance, and of some mechanical difficulty, namely: how to connect the body of the hat with the flexible head-band carrying the draw-cap, which band is concentric within the hat at a distance of, say, half-an-inch all round, in which space it has to expand and contract towards the centre, and therefore must exercise no tension on the hat itself, which will not contract. Yet the hat must have a firm connexion with the band and cap, the latter having to carry it, and to endure any heavy blows directed upon it without the connexions giving way; and the band, when tightened, having to keep the hat rigidly fixed and equidistant from itself at every point. Lastly, this peculiar provision must be simple, durable, and inexpensive. We have, in this, a mechanical problem of more difficulty than many which are more showy and apparently important in their solution, though few questions can surpass in importance the preservation of the brain in a state of comfort and of consequent efficiency; and nothing can more conduce to its comfort, next to an exclusion of solar heat, than keeping the head as much as possible free from constriction and refreshed by air.

If we take a dozen of stout and stiff wire pins, \( R_E \), ranging from an inch and a half to two inches and a half long, and with their ends turned into eyes, and attach them in an upright position about two inches apart, each by one eye round the lower edge of the crown of the hat (the short ones behind and the long in front), and by their upper eyes to the upper edge of the head-band at equal distances all round it, we shall have a connection of great strength having these properties between the crown and the head-band,—it might be made to support the hat though a crushing weight were placed on it; and when the head-band was tightened it would resist the lifting of the hat off the head with ample rigidity, since the wires must all of them be bent double first. Again, owing to the length of the wires being fourfold their inclination, a very little angular motion of them inwards and sideways permits the band to contract or enlarge its circle unaffected by the rigidity of the hat containing it. Thus this system of wire rods, freely hinged at top and bottom, gives absolute rigidity against any vertical motion of the hat (that is, against its being forced down or being lifted off), and, at the same time, absolute freedom to the horizontal motion of the head-band in varying its dimensions. But then, without some further provision, the hat would be also free to shake about horizontally. To guard against this: on each side of the head-band, near its front central line \( r \), fig. 3, a wire is stitched across it vertically, having eyes at top and bottom, through which stout whipcords \( S S \) pass horizontally and obliquely to the crown of the hat, to which they are firmly fixed. At the back of the head the band is divided, its two ends overlapping each other. Attached to the band near each of these ends there are similar wires and cords, \( f f \), as the front ones, \( S S \); but instead of these cords being fixed to the crown of the hat, as at the front, they are formed into loops, to which are hooked two ends of the cord \( T T \), pulling in opposite directions sideways, towards
holes in the crown $U U$, through which they pass to meet at the winding on the head-band, but, through the tension of the cords laterally, prevents any play of the hinder part of the hat, as well as any motion forwards and backwards, while the cords at the front of the band equally check lateral motion there.

By this adaptation of simple means—much more simple in the construction than in the description of them—a provision is obtained admitting of great strength and durability, of trifling cost, and requiring no more intelligence in the wearer than shall suffice for twisting up the peg one way, and raising and untwisting it the other way—an action any idiot might be taught to perform. Let it be borne in mind that this, or some similar provision better than it, if forthcoming, is necessary to give comfort to the head of the soldier—and how much that comfort comprises!—and furthermore, that it would enable the same sized hat to fit, with equal comfort, all the heads in an army; the only objection to employing one size being the unnecessary bulk in the case of very small heads. Two sizes then, or at most three, would answer thoroughly for all sizes of heads; while, from its flexibility, the band would also adapt itself with equal comfort to heads of every shape.

Reverting again to the body of the hat, if it have two crowns (as in the pattern present, and in the sections, figs. 2 and 3), the inner crown ought, under all circumstances, to have both its surfaces coated with metal; not only the inner one, facing the head, but the outer surface also, which faces the interior of the outer shell: the inner surface, as already stated, that it may not so readily radiate heat upon the head as fibrous surfaces do; and the outer surface, that it may not so readily, as such surfaces also do, imbibe heat radiated from the interior of the outer shell.

Exterior to this inner crown, and over its whole surface, there is an air-space, $A A$, between it and the outer crown, $D D$, three-eighths of an inch wide, which, in the pattern helmet, is extended to the extremity of the brim, it being also double. This double construction of the brim not only gives great strength to it, but it tends also to prevent heat from penetrating to its under surface and being radiated from it upon the face, sides of the head, and neck. A circle of many holes of considerable size around the inner brim admits air of convection, which then passes up between the two crowns to the top of the hat, where it enters a chamber, $B B$, fig. 2, inclosed by a crownet, $b b$, surmounting it. This exterior current of air is not a ventilating current, but solely a current of convection to sweep off from the interior of the outer shell as much heat as it can during its constant ascent.

Becoming thereby much heated, this current is not allowed entrance anywhere into the interior of the head-chamber. It is thus given no opportunity of heating the inner ventilating current until the latter, having done its duty, flows through the central opening, $e$, in the inner crown into the coronet-chamber, $B B$, which is thus an embouchure common to both the interior ventilating and the exterior convecting current.

The coronet is a short cylinder, surrounded by circular holes of three-eighths or half-an-inch in diameter, and it is inclosed by a sliding band
of metal, pierced with corresponding holes. This peculiar construction of a hollow coronet mounted on a helmet, was designed in order to combine, under one simple arrangement, the different provisions necessary for giving adequate and secure vent to currents of air passing up a helmet or hat, and for controlling the current; also to effect this without letting in the sun's rays to the interior of the hat.

In the first place, any ventilation in a tropical climate that does not admit of being very copious, can but partially fulfill its duty; but it is in vain to offer to air a free entrance below, if it is not given a ready vent above. A few mere pinhole-apertures at top are almost useless. Yet free apertures cannot be made either at the top or sides, lest the sun's rays should penetrate them and fall upon the head, or heat the interior of the hat. If the helmet be mounted by a crest, made hollow, with its mouth opening forwards, unless the crest were quite horizontal, and had an opening of equal size facing backwards, it is manifest that even such a moderate pressure of air on its mouth as is produced by walking, would arrest the exit of any inner rising current, created by the mere warmth of the head; while the least breeze would assuredly blow inwards, and, by the shape of the crest, be turned downwards upon the head. It is only at times that the head could endure such a current of wind striking upon it at top. Against such downward blasts it is highly needful to guard.

Moreover, where there is a current of convection rising up exterior to and all round an inner crown, such a current requires some circular receptacle for its free admission and discharge into the atmosphere. The current of ventilation, therefore, ought to be under entire control. It oftentimes happens in India, even in the same day, that in the early morning the atmosphere is so cold and charged with penetrating fog that but little current of air could be endured, yet by ten or eleven o'clock the heat becomes so trying that the utmost ventilation possible would be grateful to the head; while between different seasons the extremes are, of course, far greater.

By means of the coronet these several points are, I think it will be admitted, satisfactorily attained. While the central opening in the inner crown is only about an inch and a half in diameter, the coronet is five inches, and being only one inch high, it so overhangs that central opening, that the most oblique rays of the sun cannot shine into the interior of the hat.

Being provided with holes around its entire circumference, in whatever direction the wind may blow, it finds a free passage across the chamber of the coronet, and can never, therefore, have any tendency to blow downwards upon the head; but, on the contrary, it has the peculiar property of any current blowing transversely over an aperture which is giving vent to an ascending current—namely, that of increasing the ascent of the latter by lessening the atmospheric pressure over it. By this arrangement, the utmost freedom possible is given to both the interior ventilating, and the exterior convecting, currents. At the same time, these currents are under immediate and complete control, through the sliding metal band encircling the coronet. By a motion of the thumb-piece on it, the band is turned half-an-inch sideways, and covers all the apertures in the circuit. Thus, without removing the hat, the ascent of air through it can in an instant be lessened or cut off altogether, in accordance with the wearer's sensations.

Proceeding on to the outer crown of the helmet, it is desirable that the
radiating power of its inner surface should be lessened by coating it with a
-ic film, that the passage of heat inwards may be, in some degree,
ed.

* is desirable that the body or substance of both this crown and of the one should be of a nature slowly conductive of heat; but in warding heat we must chiefly rely upon the copiousness of the up-draughts of air within each crown, especially of the ventilating draught within the inner one and around the head, and upon the nature of all the surfaces of the crowns, but most especially on the nature of the exterior surface of all.

So far as the great point in a tropical hat—resistance to the entry of solar heat—is concerned, a head-dress cannot be perfect which does not present to the sun's rays a metallic face, that is, it cannot effect its object by means of the simplest construction, and with the smallest weight of matter.*

But then, if it be given the spheroidal form of a helmet, and at the same time a metallic face, it will reflect the sun's rays in a multitude of directions, dazzling the sight of persons far and near; unless indeed their eyes should be guarded with gauze spectacles. A white surface, so long as it is brilliantly white, will be found next to a metallic in reflective efficacy; but, though it does not reflect the solar ray in certain particular directions with all equal brilliancy to metal, it has the disadvantage of reflecting the rays of both solar and diffused light in a multitude of directions, as already set forth, whatever shape be given to the head-dress. It is in some degree dazzling therefore to beholders placed almost any where around it. Therefore, having, with a view to conciliating military taste, adopted an elliptical or helmet form for the pattern, I have been compelled to relinquish the great advantage of opposing a metallic face to the sun's rays, and, to make up for it, have had to rely upon a combination of every other available agency. A stiffened felt body has been adopted for this pattern on account of the facility with which it can be formed, but, as already shown, it is a most ready receiver of the solar rays; and, though it is supported by cork blocks against the inner crown, it becomes a question how far the stiffening cement would bear the heat in India. But these details do not affect the principles of the construction, for the shell might be formed with advantage, like the first hat I made in India, of cane-work, and be then covered with white cloth, as in the helmets lately used in India. Whatever material is used for the body, since the form is opposed to metallic brightness, it ought to be provided with a tight white cover, which, when at all soiled, may be turned inside out, or exchanged for a fresh clean one. Tightness and smoothness prevent a lodgment of dust, and otherwise favour a surface's maintaining its cleanliness. Moreover a soldier could easily carry with him a spare cover, where they are so small, and could himself wash one, and stretch it on his helmet to dry and bleach in the sun.

With the protection to neighbours of the eyeguard, to be described presently, I do not think one need hesitate to propose maintaining a white exterior to the crown, and no one who has had experimental experience in India can question the reflective value of a purely white surface; though, as was to be anticipated, we are informed that the Commander-in-chief was

* Such a metallic surface may be a mere film of metal leaf on bronze, which would weigh a few grains only, and could not of course feel hot when handled.—J. J.
led to adopt the "carcey," or dust colour, for the dress of the troops, on account of the injurious glare of white.

Aided by a reflecting exterior, the various provisions of this helmet constitute a head-dress which could not, I think, be readily surpassed. *

Lastly, a protection of the eyes from the intense glare in India is greatly needed. Not only does glare, acting through the eyes, aggravate so much the effect of any causes irritating the brain, that, when the irritation becomes serious, absolute darkness has often to be prescribed, but the eyes themselves are weakened by it. Even many of the natives who are much exposed by day, can, at last, only see in a strong light; becoming blind in twilight—suffering from the complaint nictalopia; which has also affected our own soldiers at various times. I cannot imagine that musketry of precision, effective at half a mile, and artillery at two miles or more, can be duly available in the hands of men half blinded by the glare of a hot season in India. However that may be, there can be no doubt that many an inflamed eye would be saved, many a headache would subside on the line of march, instead of terminating seriously; and many a poor fellow kept out of hospital, if he could screen his eyes from an intolerable glare. Now, with such a head-dress as this, it is easy to provide him with eye guards, made of horse-hair net, inclosed in a tough flexible gimped wire, which would prove much less liable to break than spectacles of wire gauze; and would, when not used, lie concealed between the brow and the hat, to which they would be attached by slides. These eye-guards can, either one or both of them, be drawn down in a moment, and as quickly restored to their place. A provision of such importance, so trifling in cost, and admitting of being made very durable, ought surely to be adopted. The eye-guards with which this helmet is provided act, you will observe, quite well, though the first which have been made.

I proceed now to describe a hat, or shako, which, for the wearer's sake, rejoices in a metallic exterior. It is given none but nearly vertical and horizontal faces, (see figs. 4 and 5, showing a side view and section), that, while it is powerfully reflective of heat, it may not throw any rays into the eyes of persons standing either near or far off. Whatever be the altitude of the sun, rays falling upon the horizontal surfaces of the top, the ledge, or the brim, will be thrown upwards above the eyes of neighbours, excepting any much higher, as on horseback, while rays falling on the upright sides will be projected downwards, below them. The hat is made deeper

* I feel it here a duty to express to Messrs. Christy and Co., the great manufacturing firm, not my own obligations only, but, as I believe, those of the public also, whether heed shall be afforded to the effort or not, for their public spirit in producing for me, at no small trouble, those parts of the helmet which belong to their line of work, namely, the outer and inner crowns and brims. Several wooden blocks had to be made, and about a dozen and a half crowns of different materials, from which about five perfect patterns have been produced. The other parts I have obtained elsewhere, and have had the whole put together myself. I have been asked what such helmets would cost. I am not a manufacturer, and I do not suppose without an order adequate for commanding tools and practice, any manufacturer could name the lowest price; but of this I have no doubt, that, if either this or the following hat were to cost 25z., the cost would not amount to five per cent. of the value of the lives and constitutions saved, while it would be impossibly surpassed by the moral gain in every sense of the term. Moreover, I think the helmets might easily, and ought hereafter, to be made in India, to give practice and encouragement to native art.—J. J.
at back, that it may be worn quite upright, with its surfaces vertical and horizontal. Indeed, the sides slightly overhang, to insure, at all times, adequate downward projection of rays from them. The hat is given the peculiar form of steps, that, while its faces are either vertical or horizontal, it may have adequate breadth at bottom for internal freedom around the head, and, at the same time, recede so much in breadth at top that it shall neither be top-heavy, nor present a broad surface to the wind, up above the line of pressure on the brow. This form is also favourable for flexibility. I was informed by a high military authority, that the present desire at the Horse Guards was, not to command for infantry a head-dress made to resist sword-cuts, but one which should possess a flexibility and elasticity which would enable it to endure much crushing and other rude treatment.

Proceeding inwardly, it will be observed, that, relying on the magnificent effect of a good reflecting exterior, and desirous of conciliating, as far as was reasonable, existing impressions respecting size and weight, I have omitted the separate inner crown and the intervening current of convection, although they, in the main, enabled me thirty and more years ago to endure, year by year, an amount of exposure to the sun, which would have been destructive to many a person possessing far greater powers of resistance than I ever enjoyed.

The single crown, then, is lined with wadding in contact with it for a short way up, and then instead of following out the inner angles, the wadding spans across them,* forming a truncated cone, attached at top around the central aperture in the uppermost disc, which discharges the ventilating current.

I have heard that a desire has been expressed in high quarters for a head-dress that shall be suitable alike for the hottest and the coldest climates. This does not at first sight appear agreeable with reason; but if we look closely into principles, we shall find it is. If the question before us had been to provide a head-dress for service in Lapland instead of India, I would say, "take this very hat." The interior of the lining facing the head being metallized, will not invite away heat from the head, the metal being unwilling to absorb its radiations of animal heat. So also the bright exterior of the hat will less readily than any other surface dissipate by radiation, to the region of frost around, animal heat stolen from within; two important provisions. Then merely insert a soft cushion of wadded cotton or lamb's-wool into the already existing space between the head-band and the crown; and if you are actually going to Lapland, fill up the angles of the hat with loose wool, and increase the depth of the flounce round the brim as far as the sides of the face; finishing it in front with open canvas or woolen gauze for a veil. Lastly, insert a draw-string around the lower edge of the flounce, that it may be drawn close up round the neck, sides of the head, and face. With these little alterations the hat will become as well suited for the Arctic regions, as without them it is for the Tropics.

But our immediate concern is with India. The weight of either the helmet or hat with a double shell is about from a pound and a quarter to a pound and a half, with a single shell it is not above a pound. Reduce

* This wadding is not shown in the section, fig. 5.—J. J.
Improvements in Helmets, etc. for

that weight if you will; you see the sizes, reduce them if you will. You see the forms: I cannot think that of the spheroidal helmet with a coronet will encounter displeasure, even though labouring under the disadvantage of novelty; nor would any one question the martial fitness of the related one with upright sides, who had himself suffered sun-stroke under fanciful trumpery. Should head-dresses on these principles be adopted, I would exhort those who have authority in the matter, whatever modification in form or reduction in size might be decided on, not to allow alterations to be carried so far as to strangle any of the principles or to eliminate any of the provisions.

The only other point connected with dress to which I can here refer is an especial protection for the back. On the importance of wearing, as a protection against atmospheric heat as well as against chills, soft open flannel next the skin over the whole surface of the body, I have, in the work already referred to, abundantly dwelt, and have mentioned as a fact, from my own experience, that in the hot winds: a thermometer placed next the skin will stand many degrees lower under such flannel than where there is nothing but a single cotton dress over it. But to rely as a protection against the sun's rays themselves upon the slow conduct of heat by any amount of clothes touching the body is utterly vain.

If we pad the back of a tunic it will soon become saturated with accumulated ray-heat, which it will then rapidly impart to the body, while it will also suffocate the skin, which will then saturate it with sweat. But a curtain of even single white jean suspended from the shoulders and propped out from them downwards three inches from the back by little bows of steel, so as to permit the air to circulate freely between it and the body, would be found to save much suffering; and if it had, as it easily might, a bright face of tin bronze, the protection would be complete.

It is not the spinal column, over which nature has placed a mass of bone and muscle, which alone needs protection, but also the skin of the whole back right and left of it, which, being supplied with nerves communicating with the spine, transmits to it and to the brain impressions which are distressing the whole surface of the back.

Uneasiness, terminating at last in sickness, will be felt over the whole back if it be opposed for an hour or less to an ordinary fire, at a distance where the thermometer does not rise above 100 or 110 degrees of our scale. It is surprising then how any European can endure, even for half an hour, the rays of a tropical sun at 160 degrees, rays intense also with chemical influence not possessed by fire rays, an influence, when in excess, so searching to the vital powers! I was myself unable to bear for more than a few minutes an Indian sun shining in its full intensity upon the back, even though the head was well protected by a redoubtable hat, and I was always careful to have intervening between the back and the sun a mat screen, or an Indian "chattah." I never met with an European who could dispense with the chattah and actually allow the sun at an inclination to play upon his back for hours together without soon paying the penalty of such rashness.

Is it not humiliating, and something more, to think that had not our British forces been providentially supported by other native troops stepping into the place of those deserting us, and had the latter not been as infatu-
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In their course of action as in their crime, there was, after our hundred years of experience, or rather existence, in India, no such dress provided as would have saved our gallant countrymen from certain exhaustion, and the nation from being relieved of the charge of India in a very ignominious manner?

In concluding the remarks I have to offer upon dress, which on the present occasion are of necessity much curtailed, I desire to repeat that anything like perfection is not arrogated to the plans I have proposed. No one would be more gratified than myself to see them superseded by any constructions really superior in efficiency, or modified in any degree tending towards it. At the same time, there is not one member of the British public whose opinion is worth a thought, who would not protest against any neglect or strangulation of sound principles in subserviency to accustomed forms or arbitrary notions of military fashion.

The Chairman said that he had no doubt another opportunity would be afforded to Mr. Jeffreys to read the remainder of his paper on tents and barracks, which was also a subject of great interest. In the meantime, some gentlemen might wish to make some remarks on the head-dress before them.

A Member suggested whether it would not be better to have a lining of green instead of red on the under side of the rim; green was a better colour for the eyes; and asked whether the outside was intended to be metal or felt.

Mr. Jeffreys said he had no motive in selecting red. He happened to be in possession of the fabric, and he made the other to match it. It would be better to have green. With regard to the outside of a head-dress of that shape, it could not be metal. He proposed to have such a tight white cover as he exhibited, at all times over it. Metal would be most desirable; but the grand objection to metal was that the powerful reflection of the sun’s rays from a spheroidal helmet would be too much for the eye.

Captain Burgess asked what would be the cost of a helmet of the kind exhibited.

Mr. Jeffreys could not tell; but he believed there would be nothing in the cost that would stand in the way of the adoption of the hat. The cost would not amount to five per cent. of the value of the man saved.

The Chairman said the paper was one of extreme importance. For many years no attention had been paid to the clothing of soldiers; in fact we had had but one mode of clothing them for all climates, whether for Canada, whether for the East Indies, or whether for home service. We had come to our senses of late years, in consequence of the attention that had been drawn to the subject. Now there was a plan in operation by which the soldier was to be clothed in one way for home stations, in another for India and the tropics, and in another for northern climates. What had fallen from Mr. Jeffreys as to the loss of life in India from sun-stroke was notorious. Anybody who had read the accounts of our campaign in India knew that the loss of life from the effects of the climate exceeded ten times the loss of life which came from contact with the enemy. It was not only humanity, it was common sense, it was absolute economy, to
clothe our soldiers in such a way as to preserve their lives. It was a duty which the country owed to the soldiers to keep them healthy during the time they were employed in the public service. With regard to the helmet before them, which weighed one pound and a half, if it were well poised and well ventilated, the extra half-pound would be nothing upon a man's head. It would be light compared with the one pound helmet, if that was close, confined, and had no ventilation in it. They were deeply indebted to Mr. Jeffreys; and he begged to offer him the thanks of the Institution for the paper which he had read, and to hope he would continue the subject on another occasion.