SIMPLE METHODS FOR COOLING MILITARY VEHICLES.

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During the Waziristan Operations, 1937, it became obvious as summer approached that these activities would extend into or even beyond the hot weather, and that therefore conditions of extreme heat would probably be experienced by personnel in certain types of vehicles and by patients when being evacuated from the fighting area or from outside the area of operations.

As regards the latter, it has been found by actual practice that the most satisfactory method of evacuation for a majority of patients would be by air transport, but up to the present this has been limited to selected cases. This has been fully dealt with by another pen in a recent article [1].

Attention was therefore directed to two types of vehicles in which these conditions of extreme heat might, with most profit to the personnel concerned, be reduced to more reasonable levels. The two types of vehicles were armoured fighting vehicles on the one hand and ambulance cars on the other.

A. ARMoured FIGHTING VEHICLES—LIGHT TANKS AND ARMoured CARS.

In the fierce sunshine of the barren frontier the temperature inside these vehicles becomes very high. In the role for which these vehicles are often used, they may have to stay stationary for long periods at a stretch in some exposed shadeless spot; they may even have to keep the engine running during long spells in one spot ready for immediate action; or they may have to travel at a very slow pace on low gear for considerable periods on roads exposed to a pitiless sun when external shade temperatures are reaching up to the 125° F. mark.

In all these circumstances internal temperatures of the vehicles become very excessive, and metal parts are so hot that the bare skin cannot be kept against them.

Many attempts have been made to cool them and many devices are employed internally for this purpose.

But additional cooling appeared to be desirable and, therefore, several ideas were considered. Covering exposed surfaces with screens of canvas or khus-khus (see p. 248) would undoubtedly give some benefit and was considered; but the risk of fire and interference with function vetoed this proposal. White or colour washing of exposed surfaces was attempted;
but, even with gum or size added to the mixture, the wash, after drying, would not stay put when metal surfaces became heated from within. This seemed to be a pity in view of the remarkable reductions which can be achieved by this simple method.

Aluminium paint was tried experimentally on one tank, together with an unpainted control. The results were sufficiently satisfactory to justify experimental adoption, which has now been continued as a limited general use in certain areas.

The main points which were observed were as follows:—

(1) External surfaces, which are heated from within to temperatures far above any external shade temperature, obviously do not require painting.

(2) The portion of the bonnet in front of the driver's field of vision should not be painted, because the glare off the polished surface interferes with driving.

(3) Painting all other exposed surfaces with special aluminium paint, containing a minimum of driers and oil, gives good reduction of temperature.

Over the driver's seat, at the position of his head, there is a reduction of about $5^\circ F.$ when the external shade temperatures vary between $110^\circ$ and $100^\circ F.$ While in the turret, where the tank commander functions, there are reductions of $8^\circ$ to $12^\circ F.$ in temperature.

(4) Inquiry from tank crews working under field conditions indicates that temperature reductions are appreciable and satisfactory, and that the method is obviously advantageous so long as conspicuousness of the vehicle is of no importance.

If camouflage is necessary, this could be achieved by using patches of light colours, such as light green, cream, light blue, and very pale grey or khaki on the aluminium ground work. The results in reduction of temperature should not fall far short of those obtained by the plain aluminium paint.

B. AMBULANCE CARS AND LORRIES FITTED WITH BERRIDGE EQUIPMENT FOR STRETCHERS [2].

The distances covered by cars used for evacuations in the Waziristan Operations are roughly 60 miles from the area of operations to Bannu, 80 miles from Bannu to Kohat, 155 miles from Manzai to Bannu. With temperatures of $110^\circ$ up to $122^\circ F.$, and with hot, dry winds blowing, conditions inside loaded ambulance cars can be very trying for sick or wounded men.

Attention was therefore turned to methods for cooling these vehicles. It was realized that such methods should be capable of rapid adaptation to existing vehicles and should require as little structural alteration as possible.

After consideration of several methods, the use of khus-khus screens
over the whole hood of the car and over the front openings of the body was found to be effective, and these have now been provided for all vehicles employed over hot sections of the roads.

Khus-khus screens are the loosely woven mats of fibre made of coarse roots of riverside grass employed usually over the doors and windows of buildings during the dry, hot months of the year in all parts of India. The soft, loose fibres of the khus-khus are very absorbent of water. Water thrown, or trickled on to these screens is held in the substance of the screen, and, by evaporation, cools and moistens any transmitted air and any surfaces on which they are placed.

Experiments were carried out to ascertain the best method of using these khus-khus screens and the simplest method was finally adopted. Efforts to maintain a flow of water on to the screens from a tank of water fixed on the top of the body were discarded owing to the liability of the pipes to be blocked with fibres, and for the tank or the body to be damaged. Incidentally, on one road section a tunnel prohibits the use of any high excrescences above the hood of an ambulance car. Wetting of the screen has, therefore, to be done by hosing, or by hand-splashing from a bucket, before the start of a journey and during halts on the journey.

The results achieved during trials of these methods are shown in Appendices I and II, and a few results of temperature records during actual journeys of evacuation are given in Appendix III. Although the latter are not particularly convincing in themselves, compared with the more detailed and carefully recorded results shown during the trials, vide Appendix I, yet the general opinion is that definite benefit is derived from this method, especially during the dry, hottest periods of weather.

In fact, some patients complained of cold at the start of their journey, when the khus-khus was fully wetted and free evaporation was taking place.

Fig. 1.—Ready for the road. Ambulance cars protected by khus-khus screens.
T. O. Thompson

DIAGRAM

NR. 1. Khus-Khus mat for main hood cover.

NR. 2. Front Screens.

NR. 3. Diagrammatic view of screens in position.
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The car drivers also found the cooling satisfactory. So much so that, even when the cars were stationary, they used the khus-khus-protected vehicles to sleep in during hot afternoons in preference to their chappar-protected tents or even barracks.

In one type of ambulance car with Weymann body, the body has a double skin, and the exhaust pipe projects up the side of the body and ends level with the top of the roof. On one of the initial runs from Bannu to Kohat, a car of this type was fitted with a khus-khus screen over the hood. This screen caught fire from the exhaust pipe. Fortunately the driver of the following car saw this in time to prevent any serious accident.

DESCRIPTION OF THE FINAL DESIGN.

(1) Main Hood Cover.

A simple rectangular strip or mat of khus-khus screening 8 feet 5 inches by 16 feet. (Subsequent experience shows that 15 feet would be better to allow for stretching and to ensure that the screen is lashed taut against the hood.) The khus-khus should be woven parallel to the shorter side to prevent rapid loss of water when the screen is in position.

Fig. 2.—Ambulance car showing method of fixing khus-khus screen.

Strengthening side pieces of webbing are stitched round the outside edges and two strips down the length as shown in fig. 2 and strengthening corner pieces of webbing are also provided.

Five strengthening strips of bamboo are built into the fabric parallel to the shorter side.

Four brass eyelets on each shorter side are provided and lashing ropes, 5 foot lengths, are fixed to each eyelet.

Four cleats have to be fixed to the body on each side below the hood (see fig. 2).
(2) Screens over Front Openings.

(i) A single rectangular screen is provided, 5 feet 6 inches by 2 feet, with the khus-khus woven parallel with the longer side to prevent rapid loss of water when the screen is in position.

Note.—It is stated that khus-khus will not weave with a rectangular or criss-cross pattern, the staple is too short.

Strengthening edges and two central strips of webbing are provided.

The screen is fixed in position across the whole of the upper openings of the body and held by short wooden battens.

Note.—A single screen has been employed for simplicity in the manufacture of the screen and trough.

Fig. 3.—Showing front openings protected by khus-khus screens. One long screen for the two top openings with the water trough beneath, small square screens over the lower openings.

A single metal trough is fitted along the lower edge of the large screen to carry waste water away to the sides of the car—each end is sloped off as an escape spout.

Note.—A single screen has been employed for simplicity in the manufacture of the screen and trough.
(ii) Two screens, 1 foot square, for each of the lower openings, similarly made, are fastened in position. The existing wire-gauze screens are removed.

It is considered essential to deal with these two openings, because, although they are small, they directly affect the patients on the lower stretchers.

Note.—No trough is required below these screens.

The top half of the front windscreen should be removed to increase the draught, or it may merely be raised.

The driver and attendant have to be provided with goggles owing to the dust which blows in when the windscreen is wide open.

In conclusion, it is hoped that the account given above, together with the illustrations, will enable others to adapt these methods to vehicles under similar conditions when required.

My thanks are due to Major-General W. H. Hamilton, C.B., C.I.E., C.B.E., D.S.O., K.H.P., I.M.S., D.D.M.S., Northern Command for permission to send this account for publication. It was on his advice that khus-khus screens were first tried out. Also to Major R. G. Breadmore, O.B.E., A.M.I.M.E., R.I.A.S.C., Commanding the Experimental Section, and to Captain J. I. Vallance, R.A., at the Experimental Section, for their help in carrying out the experimental work and making the designs.

REFERENCES.


APPENDIX I.

AMBULANCE COOLING TEST CARRIED OUT BY O.C. EXPERIMENTAL SECTION.

Morris Ambulance Car.

Test No. 1.

May 17, 1937. Tested as standard. Left out in the sun for four hours. The vehicle was stationary.

<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature in shade °F.</th>
<th>Sun temperature °F.</th>
<th>Temperature in body °F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.00</td>
<td>92</td>
<td>109</td>
<td>93</td>
</tr>
<tr>
<td>11.00</td>
<td>94</td>
<td>110</td>
<td>101</td>
</tr>
<tr>
<td>12.00</td>
<td>97</td>
<td>128</td>
<td>109</td>
</tr>
<tr>
<td>13.00</td>
<td>99</td>
<td>130</td>
<td>112</td>
</tr>
<tr>
<td>14.00</td>
<td>99</td>
<td>128</td>
<td>114</td>
</tr>
</tbody>
</table>

Test No. 2.

May 18, 1937. Tested with dry khus-khus placed over the body, allowing no air space between the khus-khus and the body. Left out in the sun for four hours. Stationary.
Test No. 3.

May 19, 1937. Tested with dry khus-khus placed over the body with raves used in order to form an air space. Left out in the sun for four hours. Stationary.

<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature in shade °F.</th>
<th>Sun temperature °F.</th>
<th>Temperature in body °F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.30</td>
<td>90</td>
<td>119</td>
<td>92</td>
</tr>
<tr>
<td>10.30</td>
<td>94</td>
<td>126</td>
<td>95</td>
</tr>
<tr>
<td>11.30</td>
<td>94</td>
<td>131</td>
<td>100</td>
</tr>
<tr>
<td>12.30</td>
<td>97</td>
<td>138</td>
<td>105</td>
</tr>
<tr>
<td>13.30</td>
<td>97.5</td>
<td>132</td>
<td>107</td>
</tr>
</tbody>
</table>

Test No. 4.

May 20, 1937. Tested with wet khus-khus placed over the body with raves used in order to form an air space. Left out in the sun for four hours. Stationary.

<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature in shade °F.</th>
<th>Sun temperature °F.</th>
<th>Temperature in body °F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.45</td>
<td>90</td>
<td>110</td>
<td>89</td>
</tr>
<tr>
<td>10.45</td>
<td>93</td>
<td>127</td>
<td>92</td>
</tr>
<tr>
<td>11.45</td>
<td>94</td>
<td>130</td>
<td>94.5</td>
</tr>
<tr>
<td>12.45</td>
<td>96</td>
<td>132</td>
<td>95</td>
</tr>
<tr>
<td>13.45</td>
<td>96</td>
<td>120</td>
<td>97</td>
</tr>
</tbody>
</table>

APPENDIX II.


(i) Ambulance with complete khus-khus screens and water apparatus with canvas hood funnel.

9 a.m.—12.30 p.m.  Very light S.E. air blowing

<table>
<thead>
<tr>
<th>Temperature in shade °F.</th>
<th>Sun temperature °F.</th>
<th>Temperature in body °F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>94.5</td>
<td>67.5</td>
<td>99</td>
</tr>
</tbody>
</table>

Shade temperature in sun  99

Note.—This is air temperature in the sun; not the ordinary so-called sun temperature

Note.—Without wetted screen temperature inside would have been anything from 100-105°F.

Temperature in ambulance car with khus-khus wet

Temperature taken by swinging in centre of car

Running at 15 miles per hour—

After 400 yards  87.5  71  Note.—Running with breeze

1/2 mile  86  70

Later  85.5  69.5  

Shade temperature on road. Higher than in depot, i.e. now 100  69
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Return journey—

Temperatures of ambulance car
Later

Dry °F  Wet °F
88 72
87 70
86 70

Note.—Running with breeze Turning into Chaklala.

Note.—One screen has been woven with fibres horizontal, the other with fibres vertical. In the vertical screen the water runs to waste rapidly, the screen is half dry and there is an increase of 4° F. at 18 inches in rear of this screen compared with the horizontal fibre screen.

(ii) Ambulance car with khus-khus screens but all funnel devices removed and top half of windscren removed.

Note.—Running with breeze Turning into Chaklala.

Shade temperature 102·5° F. Note.—Wet bulb thermometer was unfortunately broken

<table>
<thead>
<tr>
<th>Temperature in car</th>
<th>Centre high °F</th>
<th>Centre low °F</th>
<th>Behind right screen °F</th>
<th>Behind left screen °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing</td>
<td>95·5</td>
<td>95</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>Running 15 m.p.h.</td>
<td>87</td>
<td>88</td>
<td>88</td>
<td>84</td>
</tr>
<tr>
<td>½ mile</td>
<td>85·5</td>
<td>88·5</td>
<td>82</td>
<td>84</td>
</tr>
<tr>
<td>Down wind later</td>
<td>87</td>
<td>89</td>
<td>86*</td>
<td>84</td>
</tr>
<tr>
<td>Later</td>
<td>87</td>
<td>89</td>
<td>86*</td>
<td>83</td>
</tr>
<tr>
<td>Returning</td>
<td>87</td>
<td>89</td>
<td>86*</td>
<td>84</td>
</tr>
</tbody>
</table>

* Screen became dry owing to blocking of feed pipe.

(iii) Control test.

Ambulance car normal in all respects (except that it has feltex on the front hood and back screen. It has been found that this makes no appreciable difference.)

No khus-khus or any other cooling appliance.

Note.—Air temperature by this time was about 103° F.

(iv) Conclusion from this day's trials.

There is a reduction of nearly 20° F. in the temperature inside an ambulance car fitted with khus-khus screens kept damp, compared with that in a normal car fitted with the ordinary double hood.

APPENDIX III.

(i) July 9, 1937

<table>
<thead>
<tr>
<th>Inside ambulance car fully loaded</th>
<th>Air temperatures outside car</th>
</tr>
</thead>
<tbody>
<tr>
<td>o F.</td>
<td>o F.</td>
</tr>
<tr>
<td>06.30 hours. Start of journey</td>
<td>86</td>
</tr>
<tr>
<td>07.30</td>
<td>88</td>
</tr>
<tr>
<td>08.30</td>
<td>90</td>
</tr>
</tbody>
</table>

Official temperature records during the day—

Maximum 108° F. Minimum 81° F. Relative humidity 51
### June 26, 1937

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Inside ambulance car</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.30</td>
<td>Start of journey</td>
<td>fully loaded 97 ° F.</td>
</tr>
<tr>
<td>08.30</td>
<td>First halt</td>
<td>97 ° F.</td>
</tr>
<tr>
<td>11.00</td>
<td>Finish of journey</td>
<td>100 ° F.</td>
</tr>
</tbody>
</table>

Official temperature records during the day—
- Maximum: 108 ° F.
- Minimum: 84 ° F.
- Relative humidity: 43%

### June 27, 1937

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Inside ambulance car</th>
</tr>
</thead>
<tbody>
<tr>
<td>06.30</td>
<td>Start of journey</td>
<td>fully loaded 90 ° F.</td>
</tr>
<tr>
<td>08.30</td>
<td>First halt</td>
<td>97 ° F.</td>
</tr>
<tr>
<td>09.00</td>
<td>Start of return</td>
<td>97 ° F.</td>
</tr>
<tr>
<td>10.45</td>
<td>Finish of journey</td>
<td>100 ° F.</td>
</tr>
</tbody>
</table>

Official temperature records during the day—
- Maximum: 116 ° F.
- Minimum: 86 ° F.
- Relative humidity: 35%

Note.—The temperatures inside the ambulance car were taken while the car was stationary, not while it was running. The cooling effects of movement were therefore not effective at the time of reading.