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ARMORED FORCE
MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

INDEXED

Report On

TEST OF ELECTRICALLY HEATED GLOVES

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Project No. 1-21

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March 20, 1943

ARMORED FORCE MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 1-21
File No. 727-122

March 20, 1943

TEST OF ELECTRICALLY HEATED GLOVES

1. PROJECT: 1-21, Test of Electrically Heated Gloves (Hand Warmers).

a. Authority - Letter G-4, Headquarters Armored Force, Fort Knox, Kentucky, File X422.4 GNOHD, dated March 14, 1943.

b. Purpose - To determine whether there is a requirement in the Armored Force for the subject hand warmers (electrically heated gloves).

2. DISCUSSION:

Radio operators and maintenance men have the greatest need for adequate hand protection since their duties necessitate not only a high degree of finger dexterity, but also involve frequent and extended contact with cold objects of high heat conductivity. Moreover, they engage in only moderate physical activity and are thus denied the benefit of the greater body heat production and blood circulation which come with physical exercise. For these reasons, radio operators were selected as the principal test subjects in the study of the electrically heated gloves. In order to simulate actual conditions of operation, radios were placed in an M2 personnel carrier and the operators required to perform their usual duties while seated in the vehicle during each test period. The degree of protection afforded by the electrically heated gloves was compared with that given by standard winter mittens and certain other combinations at a temperature of -30°F and 25 mph wind velocity. The performance of the several types of hand protectors was observed with both the subjects adequately and inadequately clothed. Details of the test procedure and discussion of results are given in the Appendix.

3. CONCLUSIONS:

a. The electrically heated gloves were slightly superior to the other types of gloves when conditions were such that the feet were not painfully cold.

b. The electrically heated gloves were definitely superior to the other types of hand protection when the subjects' feet were painfully cold. In other words, the protective effect of the heated gloves became more apparent under more severe test conditions.

c. None of the glove combinations maintained the warmth of the hands while in contact with cold radio parts. The hands warmed most rapidly after cessation of such contact, however, when the electrically heated gloves were worn.

d. The electrically heated gloves retain their flexibility at low temperatures and allow manipulation of radio controls to be carried out with ease.

e. There is no requirement for rheostat or switch.

f. The electrically heated glove, in its present experimental form, has certain disadvantages which may be remedied.

4. RECOMMENDATIONS:

a. The electrically heated gloves as submitted for test be considered unsatisfactory for use by the Armored Force.

b. Suitable modifications as recommended in paragraph 4, Appendix "A", be made by the manufacturers.

c. The modified gloves be tested both in the field and the laboratory prior to a final decision relative to their adoption.

Submitted by:

Lt. Steven M. Horvath, Sn. C.
Lt. Arthur Freedman, M.C.

APPROVED Willard Machle
WILLARD MACHLE,
Lieut. Col., Medical Corps,
Commanding.

2 Incls:
#1 - Authority for Project.
#2 - Appendix "A" w/sketch.

HEADQUARTERS ARMORED FORCE
Office of the Commanding General
Fort Knox, Kentucky

AFB P-362
X 422.4 GNOHD

March 14, 1943.

SUBJECT: Hand Warmers.

TO : Commanding Officer, Armored Force Medical Research Laboratory, Fort Knox, Kentucky.

Confirming telephone instructions of March 1, 1943, from Major Thornbury to Lieutenant Colonel Machle, the Armored Force Medical Research Laboratory, is authorized to conduct test of Hand Warmers and submit report to this Headquarters. It was agreed between Major Thornbury and Lieutenant Colonel Machle that the report will be rendered March 15, 1943.

By command of Lieutenant General DEVERS:

/s/ C. M. Wells
C. M. WELLS,
Lieut. Colonel, A. G. D.,
Assistant Adjutant General

Incl. #1

APPENDIX

1. Test Procedures

a. Tests were conducted at -30°F and 25 mph wind velocity. The seven subjects, five of whom were radio operators, sat in an M2 personnel carrier and performed the tasks assigned to them for a period of two hours during each test. The radio operators performed their usual duties, while the other two men wrote or manipulated the machine gun or steering wheel.

b. Several glove combinations were tested for comparison with the electrically heated glove, as shown in Table I.

TABLE I

COMBINATIONS OF HAND PROTECTION TESTED

No. 1 - Glove, Heated; Glove, insert electrically wired and glove outer, leather; connected.

No. 2 - Same as No. 1 except glove not plugged to battery.

No. 3 - Ski Assembly; Mittens, shell, trigger finger; and mittens insert, trigger finger, wool O.D.

No. 4 - Glove, work, leather, lined.

No. 5 - Mittens, Fur; and Mitten, insert, trigger finger, wool O.D.

No. 6 - Mittens, Fur; and glove insert, rayon (Canadian).

No. 7 - RCAF Combination: mitten shell, leather, and mitten insert, trigger finger, wool, and glove insert, rayon.

c. Two different types of hand protection were compared on a single subject who wore one type on one hand and the second on the other. This procedure has been found to be necessary for quantitative evaluation since individuals vary so much in response to cold from one exposure period to another. Individual differences were further reduced by alternating the test periods so that a morning experiment on one day was, in essence, repeated on the succeeding afternoon.

d. Two sets of experiments were conducted, one with the men adequately clothed for exposure to -30°F and 25 mph wind velocity, and the second with the subjects not fully protected so that they suffered general body discomfort. The combination of clothing worn in the two sets of experiments are listed in Table II:

TABLE II

A. "Adequate" Protection	B. " Inadequate" Protection
Suit, Arctic, six piece	Jacket, Combat, Winter
or (Suit, wool shearling, experimental	Trousers, Combat, Winter
(Parka, fur trimmed	Helmet, Combat, Winter
Mukluks	Shirt, wool, O.D.
or	Trousers, wool, O.D.
Shoe, Felt, Canadian	Overshoes, Arctic, 4-buckle
Socks, Arctic	Socks, Arctic
Socks, wool, medium	Socks, wool, medium
Socks, wool, light	insoles, felt, or burlap
innersole, burlap	

The men dressed in an adjacent room and entered the cold room quickly to minimize sweating.

e. Observations: Rectal temperatures were obtained before and after each test period. Subjective symptoms of the subjects and particularly their evaluation of one type of hand protection against another, were recorded at frequent intervals during each test. The current consumption of the electrically heated gloves was recorded.

2. Results -.

a. The effectiveness of the protection afforded by a given type of hand covering depends only ~~on~~ in part upon the hand covering itself. The blood or body temperature and the rate of blood flow to the extremities are important factors. These are influenced by individual differences in circulation, the amount of physical activity and the adequacy of the clothing. Because of these, hand protection which is adequate when the wearer is generally comfortable may not be so when he is wearing inadequate clothing and is generally cold. Accordingly the effectiveness of the gloves was evaluated with the subjects under both conditions.

b. With adequate clothing. Results, with different combinations of hand protection, are compared in Table III on a basis of equal foot-cooling since in all cases, the trunk never became cold in these tests.

The superiority of the electrically heated glove over the other types of hand protection is strikingly demonstrated by the comparative results when the feet were painfully cold. Thus, in one-half of the tests with the heated glove, the wearer reported his hand to be "cool" or "warm", whereas, with all other glove combinations, the hand was "uncomfortably cool" or worse--the majority falling in the category of "cold with slight pain." The superiority of the heated glove was not as striking when the feet were not painfully cold, although no other combination gave protection better than "uncomfortably cool", whereas, the heated glove was reported better than this in ten of fourteen tests.

TABLE III

HAND COOLING WITH EACH TYPE OF GLOVE

(Clothing Adequate - 2 hr. exposure to -30°F., 25 MPH wind)

Glove Combinations	Body comfortable; feet not painfully cold — HAND SYMPTOMS †								Body comfortable; feet painfully cold — HAND SYMPTOMS †							
	Warm	Cool	Uncomfortably Cool	Cold	Cold with slight pain	Cold with severe pain	Numb	No. of men wearing each glove	Warm	Cool	Uncomfortably Cool	Cold	Cold with slight pain	Cold with severe pain	Numb	No. of men wearing each glove
Glove, Heated	6	4	4					6	3	3	4	2				5
Glove, Heated, not connected			3	10	2			4					4			3
Ski Trooper Assembly*				1		1		3					4		2	3
RCAF Assembly, small			1	1				2				2	1	2		2
Mitten, Fur, with mitten, wool O.D. Liner								0			1	2				2
Mitten, wool, O.D.				1	1			2					2			2
Glove, Leather, Wool, Lined					2			1								0

* Consisting of mittens, wool, trigger finger, and mittens, shell, trigger finger

† Each figure represents the responses of one hand in a single experimental period.

c. With inadequate clothing. Experiments with inadequate clothing had to be terminated before definite conclusions with respect to relative hand protection could be drawn. The limited evidence which was obtained, however, indicated that the hands remained warmest when the electrically heated gloves were worn.

d. Hand protection during and following contact with cold objects. None of the various types of gloves was effective in preventing immediate chilling of the fingers and palms when handling microphones, writing notes or manipulating radio controls. After cessation of these activities, however, the electrically heated glove warmed the hand rapidly with complete restoration of comfort. With the others, warming was much slower and, in many instances, the hand failed to return to the original level of comfort.

e. General observation. The subjects' evaluation of the various types of hand protection, taking into consideration both comfort and ease of manipulation of radio controls, are tabulated below:

Type of protection	1st Choice	2nd Choice
Heated gloves	5	2
Fur mitten with liner	1	4
Ski Trooper combination	1	1
Total number of subjects	7	7

The heated gloves were preferred by five of the seven subjects. One man, who selected the fur mitten with liner, apparently was willing to sacrifice some comfort for the dexterity afforded by this type of hand protection, in which the bulky fur outer cover could be removed quickly and a high degree of dexterity with some protection, provided by the close-fitting inner glove. This feature has considerable importance.

3. Modification of Electrically Heated Gloves.

a. The electrically heated glove is an experimental model type P-223-1, manufactured by Pioneer Products Section, General Electric Company, Bridgeport, Connecticut. The complete glove consists of an inner wool glove with a single layer on the palm and a double layer on the back. The heating elements of flexible wire are fixed between the two back layers in the arrangement shown in Fig. I. The outer glove is an unlined leather shell. The current consumption for one pair of gloves is 5 amp. at 6 volts. A number of disadvantages were noted in the present experimental model.

b. The power consumption of 30 watts required by a pair of the gloves is equivalent to a rate of heat production of 24 calories per hour. This is approximately 1/3 of the entire hourly heat output of a quietly seated man and should be more than adequate to maintain comfort of the hands provided it could be efficiently applied. Further improvement requires more uniform application of the heat and better heat insulation outside the heating elements.

c. Further indication of the need for improvement in the distribution of heat is evidenced by the inadequate protection which is given when handling cold objects. The palms, finger tips and thumb become painfully cold.

d. The gloves offer quite inadequate protection when the electric current is not on and only poor protection when the voltage is low. For example, when the electric input was reduced to 16 watts, the hands quickly became painfully cold.

e. The present wiring of the circuit with the gloves in series makes it impossible to use a single glove. Furthermore, if a short circuit occurs in one glove, both are rendered inoperative.

f. The plastic guard over the battery clip becomes hard at low temperatures and consequently the clip cannot be opened or closed.

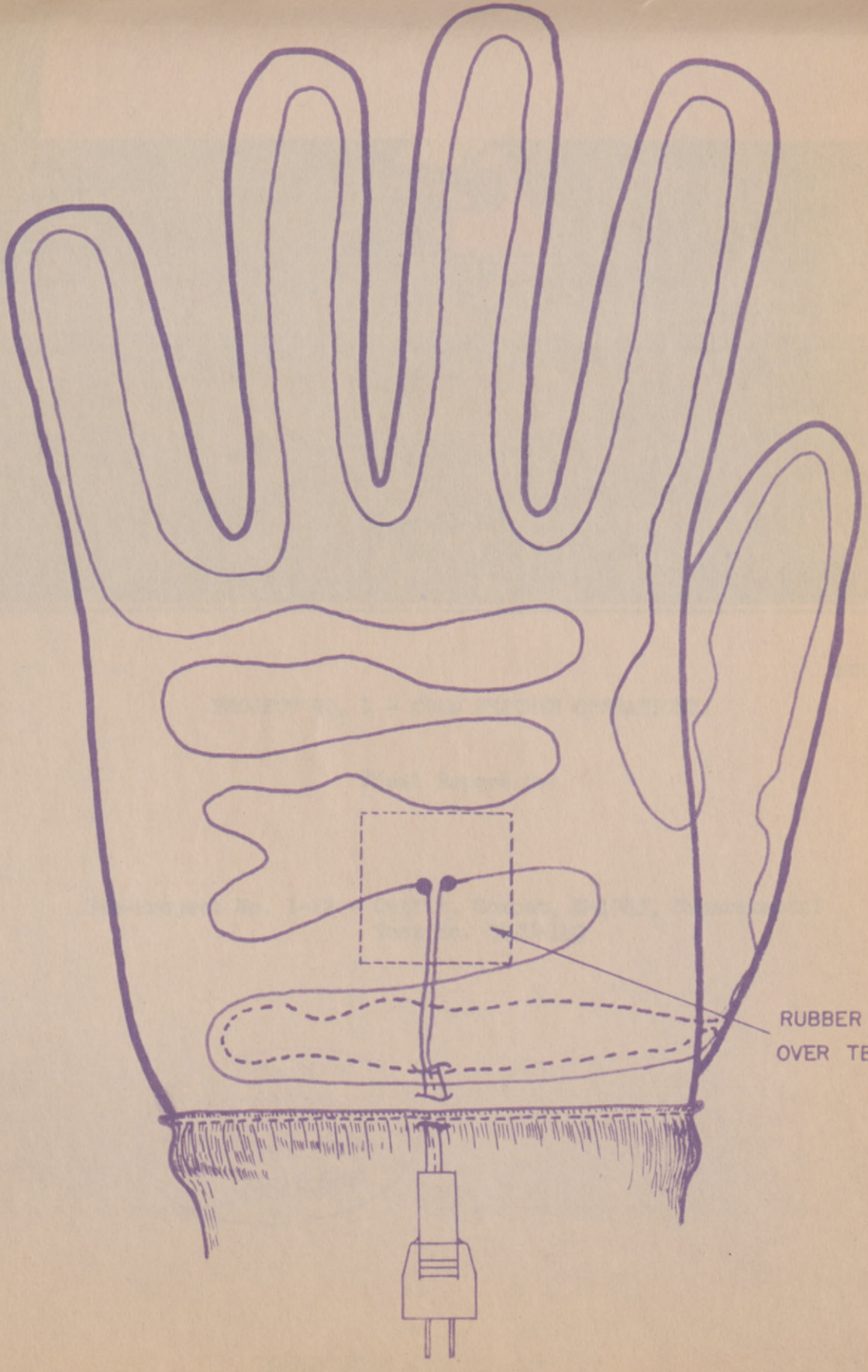
4. RECOMMENDATIONS:

a. Change circuit of the two gloves from a series to a parallel connection.

b. Develop, if possible, a more uniform distribution of heat.

c. Provide a better outer glove.

d. Provide a guard for the battery clip that will be flexible at -40°F.



GLOVE WIRING
(BACK)

FIG 1