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ARMORED FORCE MEDICAL RESEARCH LABORATORY
Office of the Commanding Officer
Fort Knox, Kentucky

October 9, 1942

EVAPORATIVE AMBULANCE COOLER

1. PROJECT: Report on Evaporative Ambulance Cooler.

a. Authority - Personal request of Colonel Blesse, Ground Force Surgeon, prior to time of submittal and approval of formal projects.

b. Purpose - To determine the degree of cooling obtained under a variety of conditions in an ambulance fitted with an evaporative water cooler of the type in current use at the Desert Training Center.

2. CONCLUSIONS:

a. The data obtained does not warrant other than tentative conclusions and indicate (1) That at low ambulance speeds the amount of cooling is of little consequence.

(2) That at higher ambulance speeds (above 25 mph) the cooling becomes significant and should offer a measure of relief to an occupant suffering from heat stroke or exhaustion.

(3) Ventilation is roughly directly proportional to ambulance speed and at 40 mph is about 1500 cfm.

(4) On stopping, after driving with the cooler in operation, the temperature increases rapidly and reaches outside air temperature in a few minutes. This temperature is accompanied with a rapid rise in relative humidity.

3. RECOMMENDATIONS:

On stopping after running with the cooler in operation, patients should be removed from the ambulance as soon as feasible since, in a few minutes, because of rise in both temperature and humidity, the ambulance atmospheric conditions become less comfortable than the outside.

Relief cooling should not be expected when the relative humidity is high.

Used as it is, in a region of low humidity, the cooler is an efficient and useful aid.

STATEMENT NO. 1

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4. PROCEDURE:

Two ambulances—one with cooler in operation and the other without cooler were driven over the same route at the same time. Inside air temperatures, wall temperatures, ralative humidities, etc. were taken before and after various operating conditions. The results are tabulated in Table I.

Air velocities at the cooler outlet, air temperatures and humidities within the ambulance equipped with cooler were determined over a range of speeds. Results are shown graphically in Figure I.

Air temperatures and humidities were determined in the ambulance during and after a run at 30 mph with the cooler in operation. Results are shown in Figure II.

5. DISCUSSION:

The fact that the humidity is still not very high after passing through the cooler indicates that still lower temperatures could be obtained with a cooler of the same type designed to evaporate more water into the same volume of air.

The limitation of the cooler not functioning with the ambulance stopped and cooling only slightly at slow speeds can be overcome by utilizing a blower to supply the air. A suggested cooler design based on the above is appended.

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Director

APPENDIX

Attached sketch illustrates a proposed Evaporative Cooler for Desert Zone ambulance application.

DESCRIPTION:

Water, contained in a tank above wetting surface, flows by gravity and absorption through wicking to a porous material (See Fig. A) Outside air, having a low wet bulb temperature, passes over and through the wetted surface, past eliminator plates, to remove excess moisture, then downward through a two-way deflecting grille located in the ceiling of the vehicle, slightly to the rear of the driver's seats. Drain water from eliminator plates flows into a trough and out of the vehicle.

In addition to the illustrated equipment a propeller type fan should be provided to be located on either side or the rear, near the top of the ambulance body. The fan should deliver not less than 1000 cfm operating against a total estimated pressure of 3/8" H_2O. The fan should have a weather louvre protecting it from rain and should be directly connected to a motor operated from a battery. The power requirement is estimated not to exceed 1/4 H.P. This is more than the car battery can probably handle in addition to its regular load and it will probably be necessary to provide a separate battery to run the fan. Increased generator capacity to keep both car and fan battery properly charged will probably be required. The fan may be operated at any or all times, however, at constant driving speeds of 25 mph or higher it will not be necessary to operate fan. Given area is such as to provide velocities of approximately 300 feet per minute through gross area.

For effective use of this evaporative cooling apparatus, vehicle should be operated with closed windows, cowl and doors.

AMBULANCE TEMPERATURES

The following temperatures were taken in a Dodge 4 x 4 Cross Country ambulance fitted with an evaporative cooling device, and also in a Dodge 4 x 4 Cross Country ambulance, stock model.

LEGEND:

1, 2, 3, etc. - Uncooled ambulance
1c, 2c, 3c, etc. - Cooled ambulance
Δ - Difference in Temperature between cooled and uncooled ambulance
Hum - Relative humidity inside uncooled ambulance
Hum C - Relative humidity inside cooled ambulance
Hum O - Relative humidity outside air

SURFACE TEMPERATURES

	1	1c	Δ	2	2c	Δ	3	3c	Δ	7	7c	Δ	% Hum	% Hum C	% Hum O	Run
11:30	39	39	0	38	39	+ 1	40	41.5	+ 1.5	36	38.0	+ 2	23	-	23	Start
12:40	41	40	- 1	42	41	- 1	43	42.0	- 1.0	38.5	37.0	- 1.5	30	34	-	|
2:00	39	36	- 3	39	36	- 3	40	36.0	- 4.0	38.0	32.3	- 5.1	28	29	12	|
3:16	39	42.3	+ 3.3	41	41	0	40	43.0	+ 3.0	38.3	39.8	+ 1.5	-	-	5	Start
4:30	40	34.9	- 5.1	37	37	- 2.5	40	36.0	- 4.0	40.0	36.0	- 4.0	26	29	9	|
5:30	39	36.2	- 2.8	37	37	- 1.5	38.5	37.0	- 1.5	38.5	35.0	- 3.5	32	28	-	|

AIR TEMPERATURES

	1	1c	Δ	2	2c	Δ	3	3c	Δ	4	4c	Δ	5	5c	Δ	6	6c	
	96	99.5	+3.5	96	100	+ 4.0	95	95.5	+ 0.5	96.0	97.0	+1.0	98	99	+ 1.0	-	101.8	-
	98	101	+3.0	101	101	0	100	99.0	- 1.0	101.0	99.0	-1.0	101	96.1	- 4.0	102.4	101.6	- 1.2
*	98	93	-5.0	100	94	- 6.0	100	93.0	- 7.0	100.5	92.0	-8.5	102	91.4	-10.6	102.2	86.0	-16.2
	99.5	103	+3.5	100	102	+ 2.0	100	102	+ 2.0	101.0	102	+1.0	101	102.4	+ 1.4	101.3	103.0	+ 2.7
	102	93	-9.0	103	94	- 9.0	103	93	-10.0	105.0	97.0	-8.0	107	97.0	-10.0	104.0	92.8	-11.2
	98	94	-4.0	100	99	-1.0	101	97	- 4.0	100.5	98.5	-2.0	102	96.8	- 5.2	100.4	94.5	- 5.9

TIME

11:30 - Starting temperature
12:40 - 1 hr. & 10 min. drive at 8 mph
(2:00) 14:00 - After 2 hr. run at 8 mph (reversed direction)
(3:16) 15:16 - Starting temperature
(4:30) 16:30 - Temperature after 1 hr. drive at 40 mph
(5:30) 17:30 - Temperature after 2 hr. drive at 40 mph (reversed direction)
* Headwind (about 10 mph)

LOCATION OF THERMOMETERS

1. Right Wall
2. Left Wall
3. Ceiling
7. Center
1. Right upper
2. Left upper
3. Right Lower
4. Left Lower
5. Driver
6. Intake

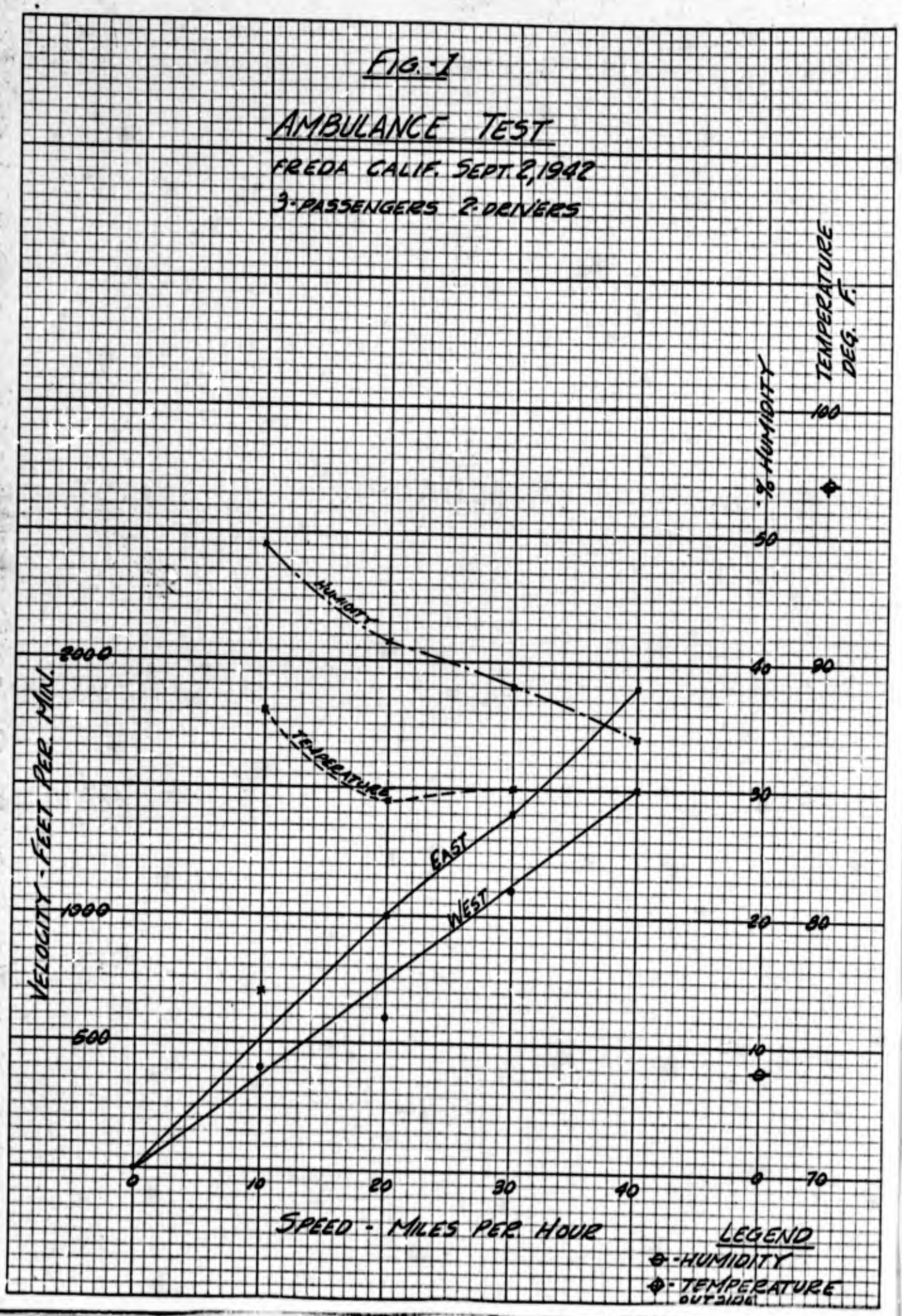


FIG. 1
AMBULANCE TEST
FREDA CALIF. SEPT. 2, 1942
3 PASSENGERS 2 DRIVERS
VELOCITY - FEET PER MIN.
2000
1000
500
HUMIDITY
TEMPERATURE
EAST
WEST
0
10
20
30
40
SPEED - MILES PER HOUR
% HUMIDITY
TEMPERATURE DEG. F.
100
90
80
70
50
40
30
20
10
0
LEGEND
HUMIDITY
TEMPERATURE OUTSIDE

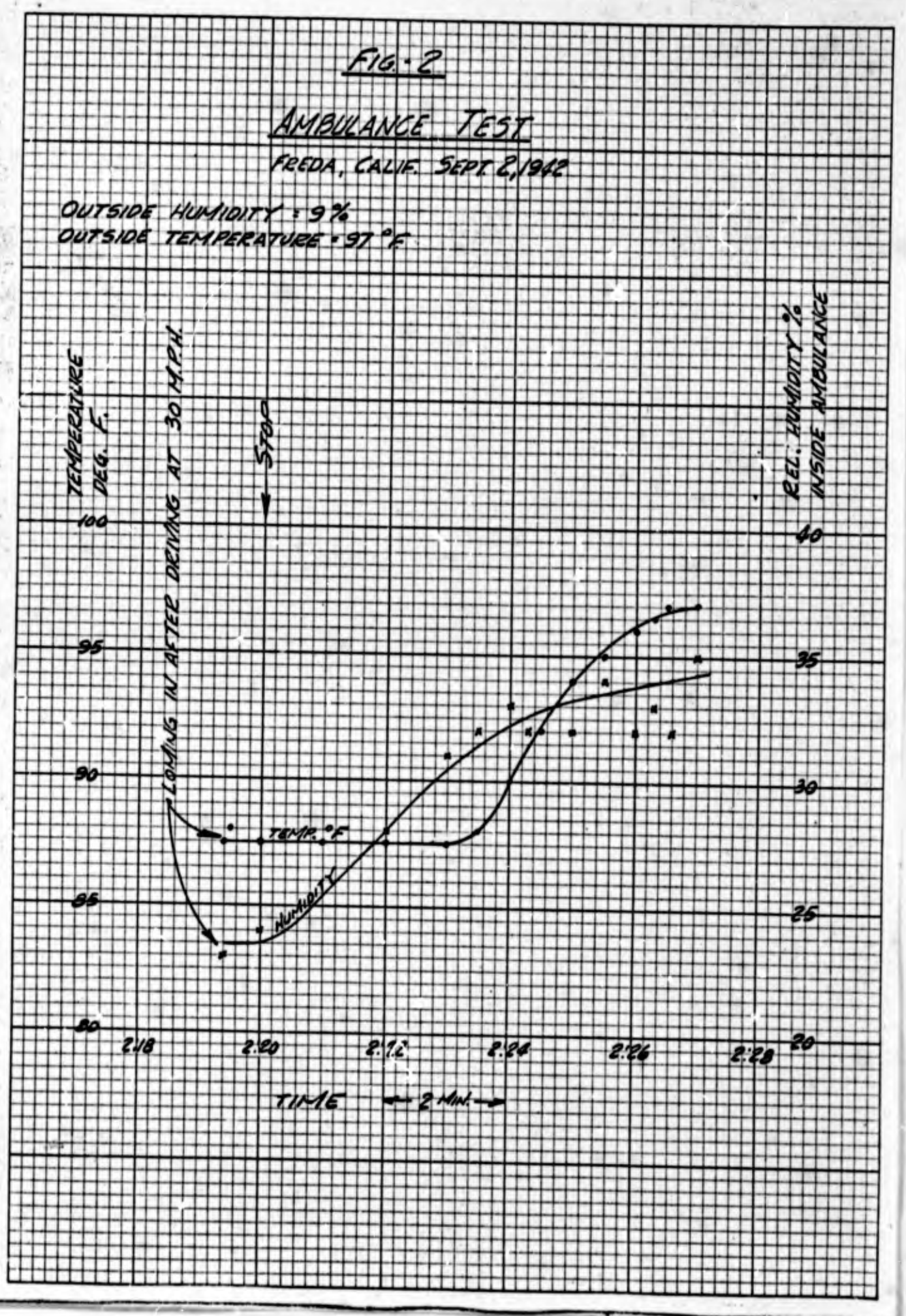
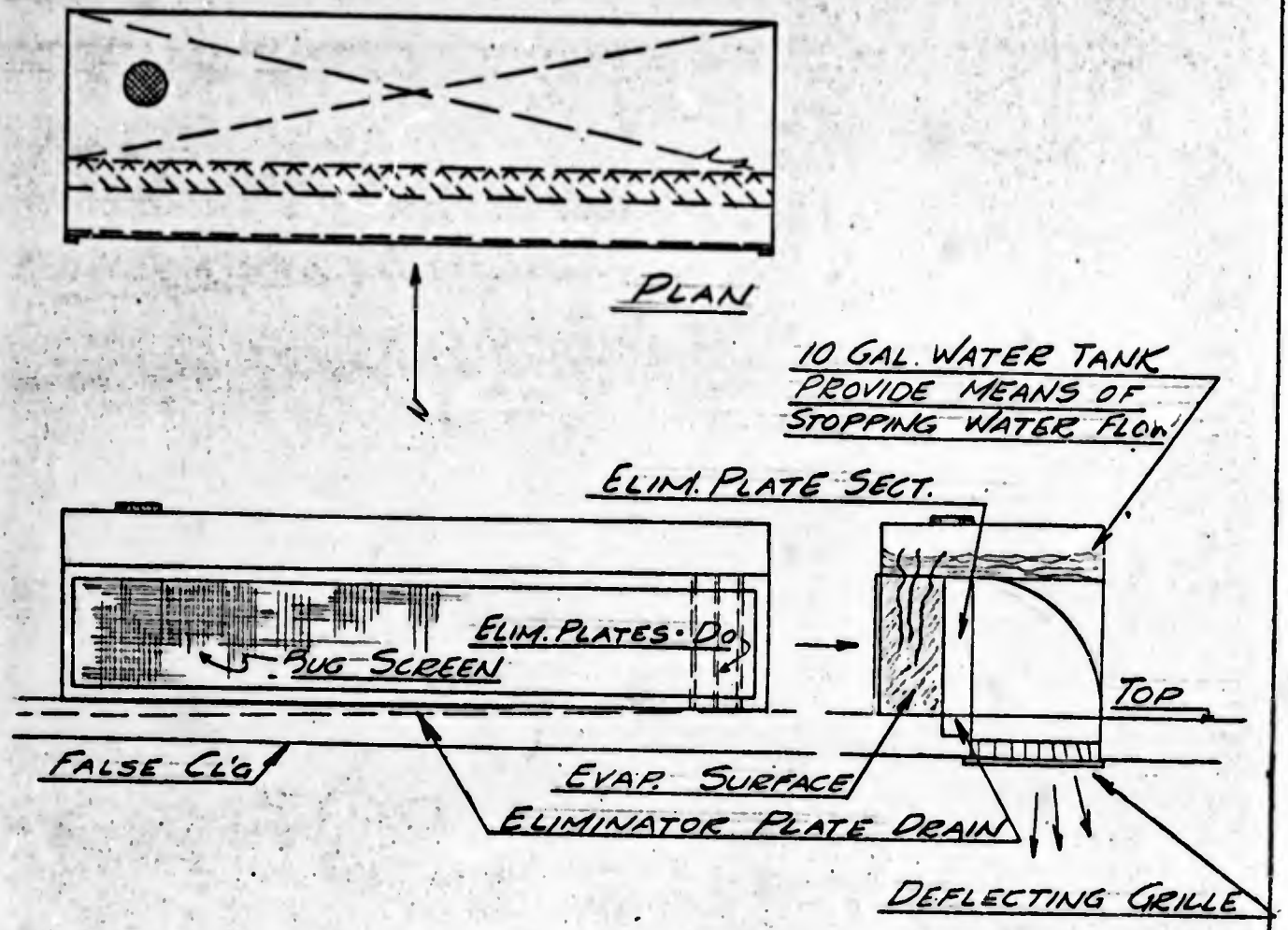
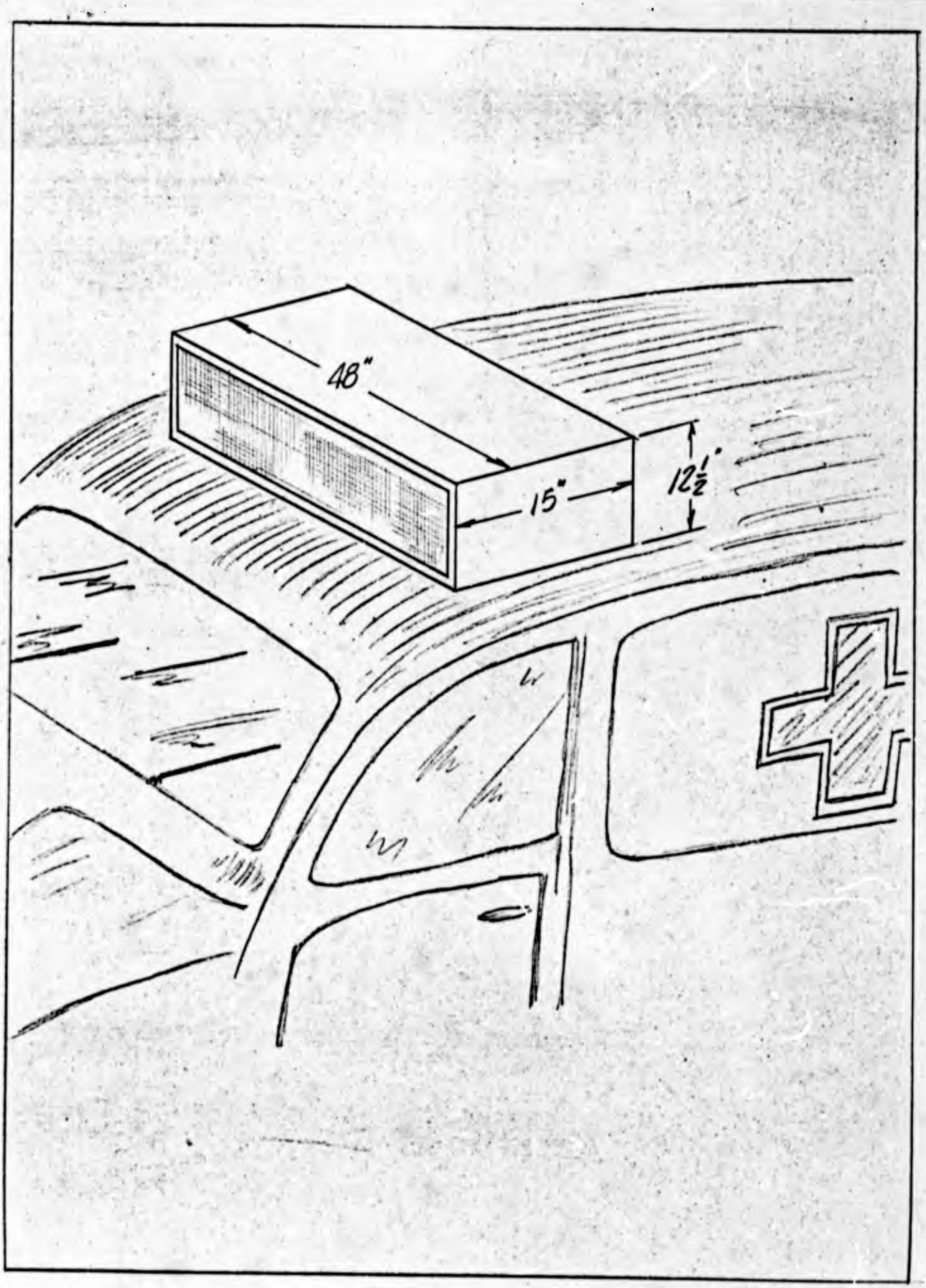


FIG. 2
AMBULANCE TEST
FREDA, CALIF. SEPT. 2, 1942
OUTSIDE HUMIDITY = 9%
OUTSIDE TEMPERATURE = 97 °F
TEMPERATURE DEG. F.
REL. HUMIDITY % INSIDE AMBULANCE
LOADING IN AFTER DRIVING AT 30 M.P.H.
STOP
TEMP. °F
HUMIDITY
100
95
90
85
80
40
35
30
25
20
2:18
2:20
2:22
2:24
2:26
2:28
TIME
2 MIN.



- OVER-ALL 48" x 15" x 12½"
- CAPACITY - 1000 c.f.m.

PROPOSED EVAPORATIVE AMBULANCE COOLER FOR DESERT ZONES


48"
15"
12½"