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A PORTABLE DEVICE FOR THE MEASUREMENT OF EVAPORATIVE WATER LOSS

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I. Introduction.

Haywood and Shoemaker have stated, "Many investigators . . . have demonstrated an increase in palmar sweating associated with the imposition of some anxiety-arousing stimulus situation into the subject's life."[1] A method for measuring evaporative water loss by using a thermal conductivity cell as a moisture detector has been described by Adams et al.[2,3] and has been used to measure palmar sweat production[4,5,6]. The method reported by Adams is precise, stable, and sensitive, but is dependent upon a 110 V AC power source. This report describes modifications of the method which permit its use in aircraft or in other field situations where electrical power sources are varied or non-existent.

II. Description.

The original method has been modified to provide a lighter, smaller, simpler device with self-contained DC power sources. The modifications include the use of proportional heater control and minor changes in the bridge circuit.

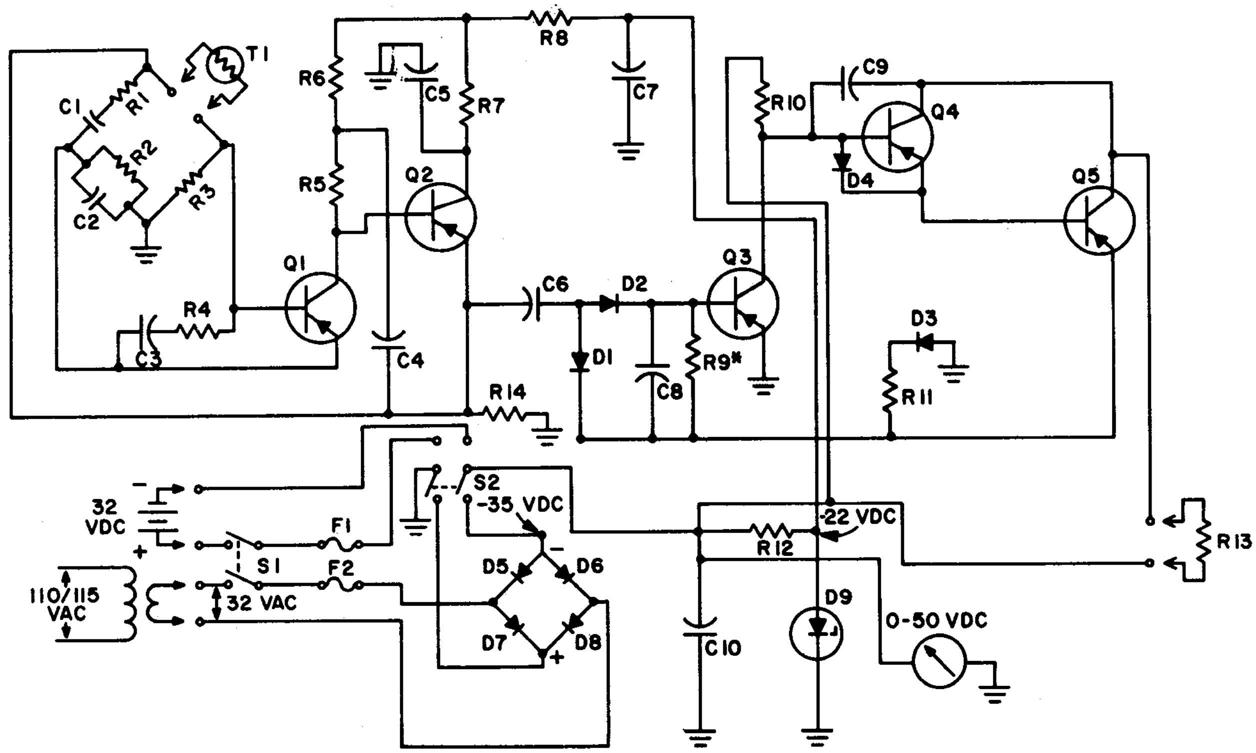
The "off-on" type of heater control maintains a nearly constant temperature more precisely when the heater voltage is adjusted so that heat gain in the constant-temperature enclosure is slightly greater than heat loss. Variations in environmental temperature consequently necessitate readjustment of the heater voltage to obtain maximum control precision. Proportional heater control, on the other hand, automatically provides maximum heater output for the initial rise to operating temperature, and thereafter continuously adjusts heater voltage to maintain the operating temperature. Changes in environmental temperatures commonly encountered in field studies do not affect temperature stability with this system. The proportional heater control circuit is shown in Fig. 1.

No temperature indicator has been incorporated into this unit; however, a thermistor was mounted inside the constant-temperature enclosure with an external jack. The jack provides a means of connecting a YSI[1] Tele-thermometer for checking temperature stability when heater malfunction is suspected.

The bridge for the thermal conductivity cell has been changed to exclude the potentiometers for voltage, coarse current, and sensitivity adjustments (Fig. 2). The voltage to the bridge was reduced to six volts, permitting deletion of the voltage and coarse-current potentiometers. Sensitivity can still be regulated by varying the size of the moisture pick-up capsule or by placing an appropriate resistor in series with the recorder. The voltmeter in the circuit could also be eliminated because its only function is a rapid check of bridge battery condition.

Three six-volt nickel-cadmium batteries (Eveready, N67) were used, one in the bridge circuit and two connected in parallel to drive a 12-volt Pittman miniature motor (Model DC–71B) fitted with a one-inch nylon propeller located inside the constant-temperature enclosure. Operation of the fan motor at six volts provides ample mixing of air. Two 16-volt batteries (Eveready, N40) were connected in series to the proportional heater control as shown in Fig. 1. The use of the 32-volt transformer to operate the heater and a battery eliminator to drive the stirring motor prior to actual testing conserves battery power. At present, recordings are made on a Mosely strip-chart recorder (Model 680) powered by a

[1]YSI; Yellow Springs Instrument Co., Yellow Springs, Ohio.



* Indicates Selected Component.

Q1, Q2, Q3 – 2N652A
Q4 – 2N383
Q5 – 2N1183B
C1 – .1μf
C2 – .047μf
C3 – .022μf
C4, C5, C6, C7, C8 – 4.7μf
C9 – 20μf
C10 – 500μf
F1, F2 – .5 amp
T1 – YSI Thermister Probe Type 417

R1 – 600Ω 1/2 W
R2 – 2200Ω 1/2W
R3 – 1027Ω 1/2W
R4 – 22Ω
R5, R6 – 4300Ω
R7, R14, – 820Ω
R8 – 100Ω
R9 – 12KΩ
R10 – 18KΩ
R11 – 6.8Ω 1W
R12 – 400Ω 3W
R13 – 150Ω Oven Heater

D1, D2 – Si – 50 at 1V 200 ma PIV
D3, D5, D6, D7, D8 – 1N2070
D4, – Ge – 100 ma at 1V 60 PIV
D9 – 1N1597A 22v Regulator
S1 – Dpst – ON OFF
S2 – Dpdt – AC – DC Operation

FIGURE 1. Diagram of proportional heater control circuit.*
*Reproduced by permission of Hewlett-Packard Company, Palo Alto, California; modification of Oven Control Assembly 5243A–65T.

12-volt Centralab Power Pack (Crl–1200) through a Terado 12 V DC to 110 V AC converter (Model 50122).

Air for the pneumatic system is supplied by a 96 cubic-inch gas cylinder fitted with a K-valve and a Cornelius Company pressure-reduction regulator (Model 2). The air passes through a small cylinder filled with "Drierite" to a Nupro-fine needle valve (Model B4M), then through the reference side of the thermal conductivity cell to the moisture pick-up capsule. The air is returned from the capsule through the other side of the cell and is exhausted through a flow meter. After the proper flow rate is established, the flow meter is disconnected.

Shielding of electrical connections to the thermal conductivity cell was not necessary, probably because of the elimination of AC voltage from the circuits.

The batteries mentioned above will operate the heater and stirring motor for four to five hours. The recorder will operate approximately

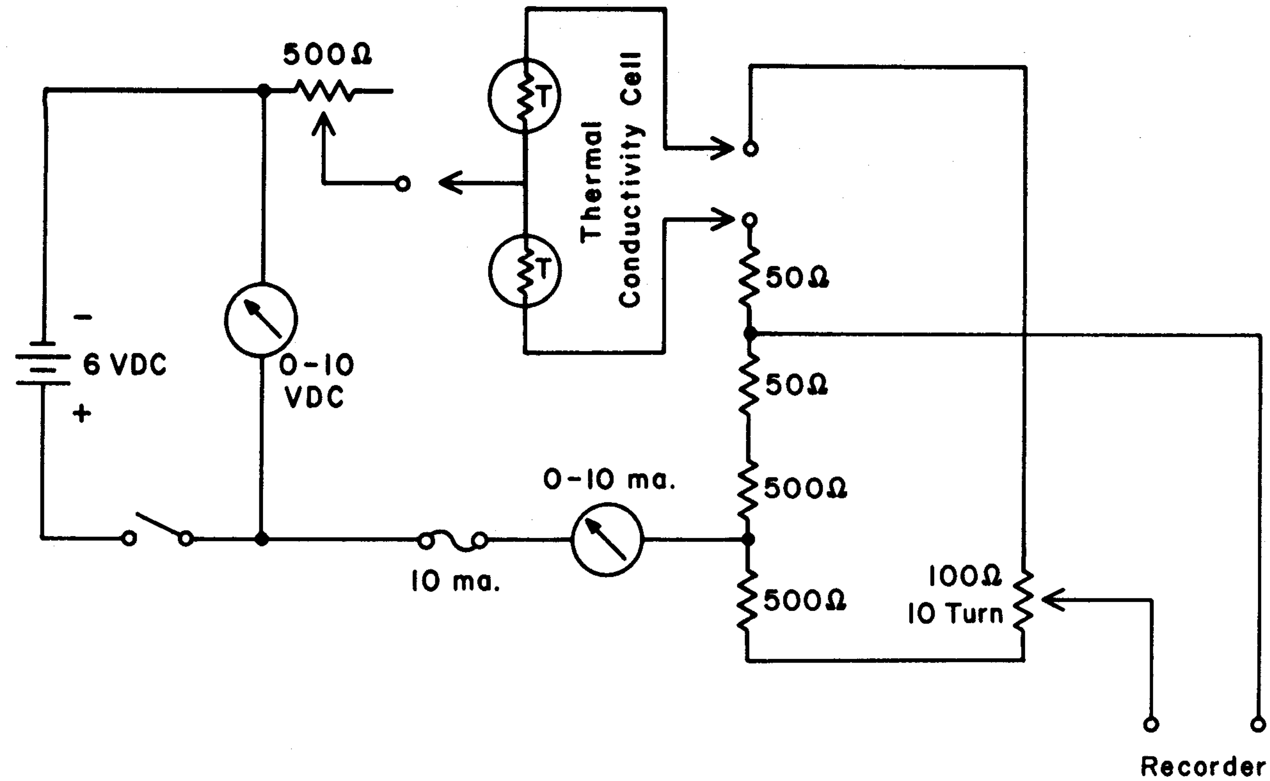


FIGURE 2. Diagram of cell bridge circuit.

two hours powered through the converter. Continuous operation could be extended by placing more batteries in parallel with the existing batteries. Work is now underway to find a suitable technique for recording on magnetic tape.

A photograph of the complete apparatus is shown in Fig. 3. Figure 4 presents a photograph of the unit in use aboard an airplane in which it was successfully flight-tested.

III. Calibration.

The system was calibrated by introducing water vapor through the pick-up capsule and collecting the water vapor in "Drierite"-filled bottles connected to the exhaust end of the pneumatic circuit. Air streams with different water vapor concentrations were produced by placing the pick-up capsule over the top of a short plastic rod which had been drilled to give a series of concentric chambers. Water was introduced through the bottom of the assembly with a syringe. The collection bottles were weighed to 0.1 mgm before and after the collection period. Recorder deflection in mV was plotted against the weight of the water collected to yield the calibration curve shown in Fig. 5.

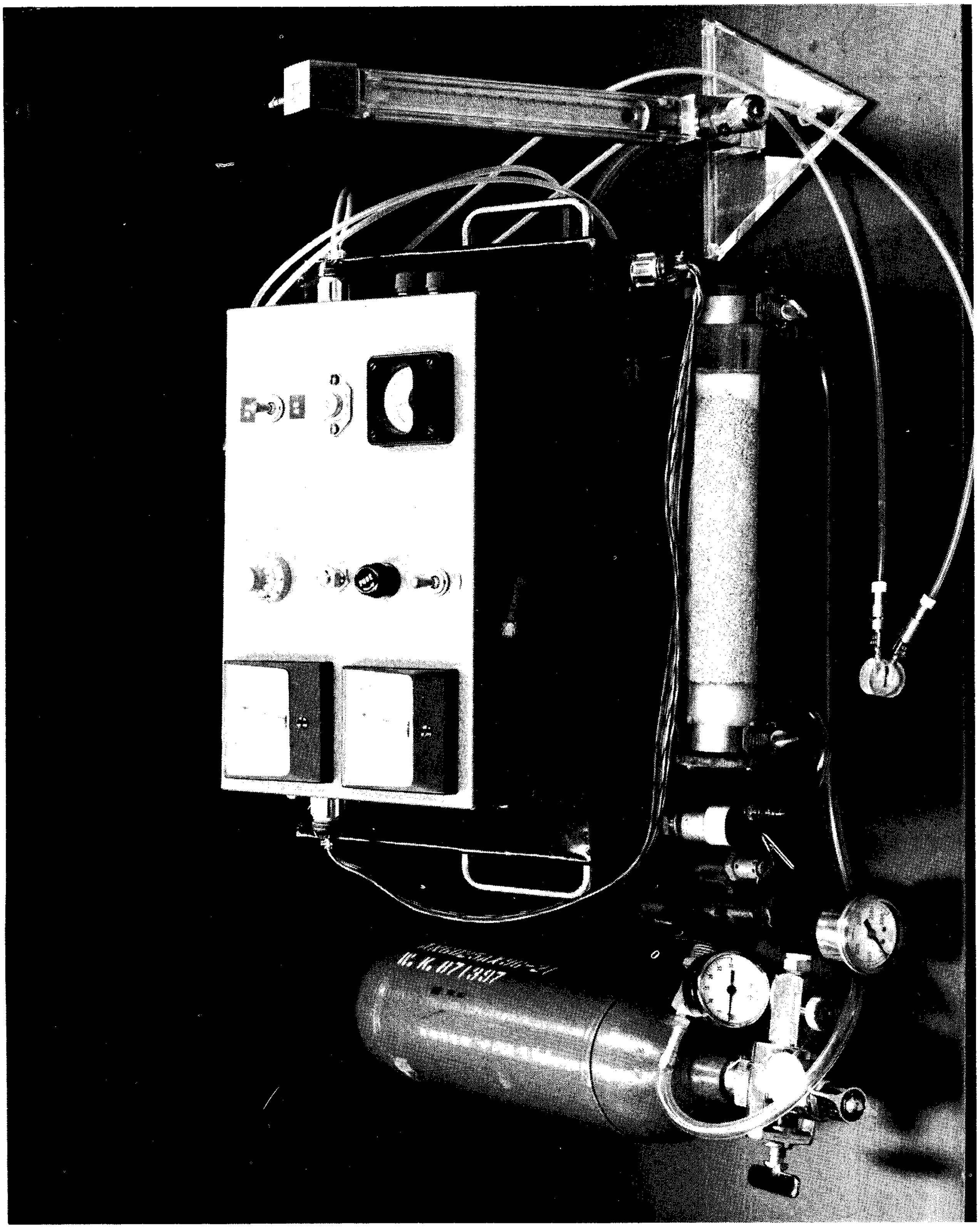


FIGURE 3. Portable evaporative water loss device.

FIGURE 4. Portable evaporative water loss device in use.

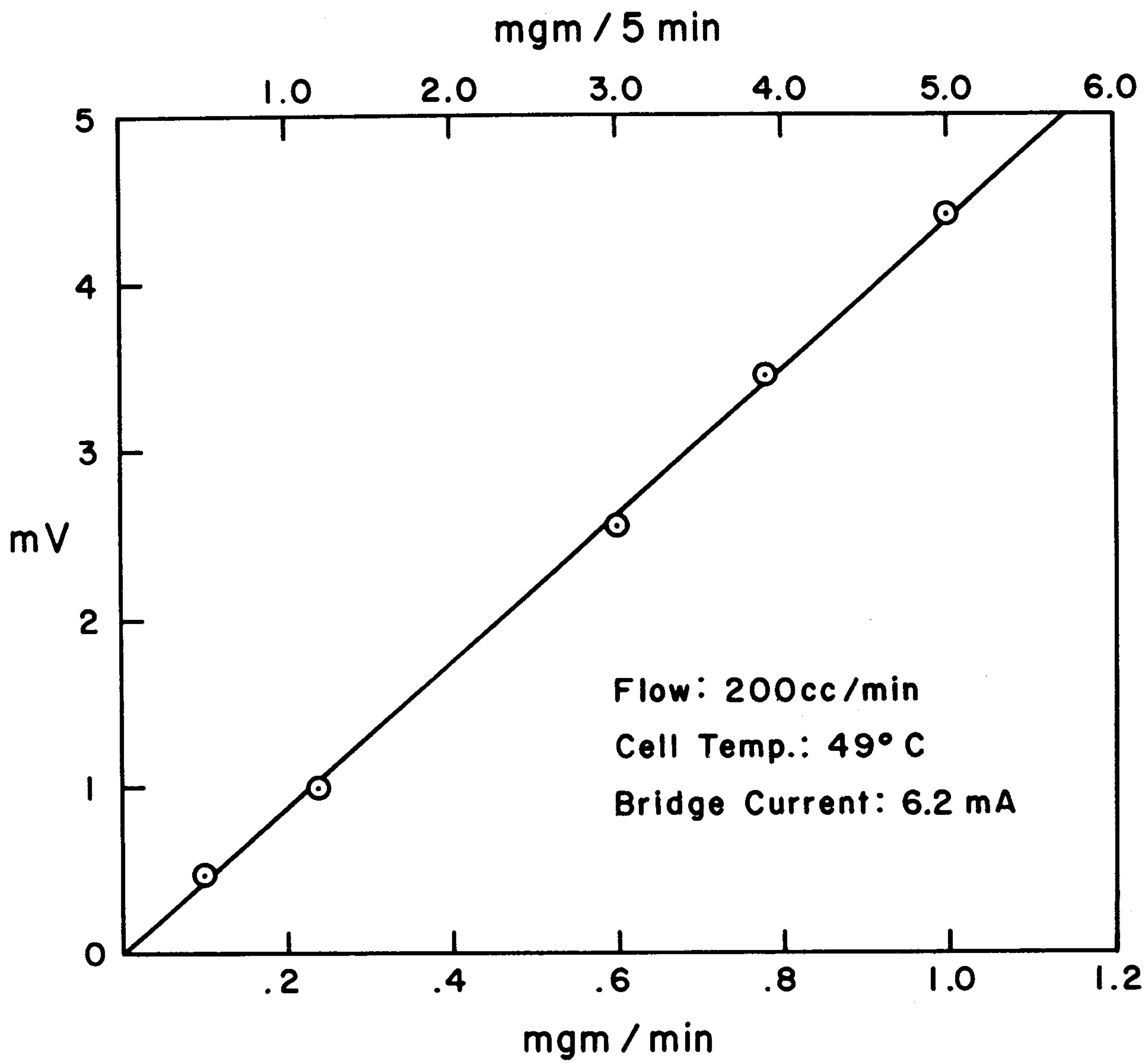


FIGURE 5. Calibration curve for portable evaporative water loss device.

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