NASA TECH BRIEF

NASA Headquarters

Breathing – Metabolic Simulator

The problem:

Thorough evaluation of life support and resuscitation equipment requires the use of human subjects. Such a requirement, however, is not practical because no two humans provide an identical load to the equipment and no single individual is capable of supplying consistent load requirements. Thus, the only way to obtain meaningful evaluation of life support and resuscitation equipment is to use an apparatus which simulates human breathing.

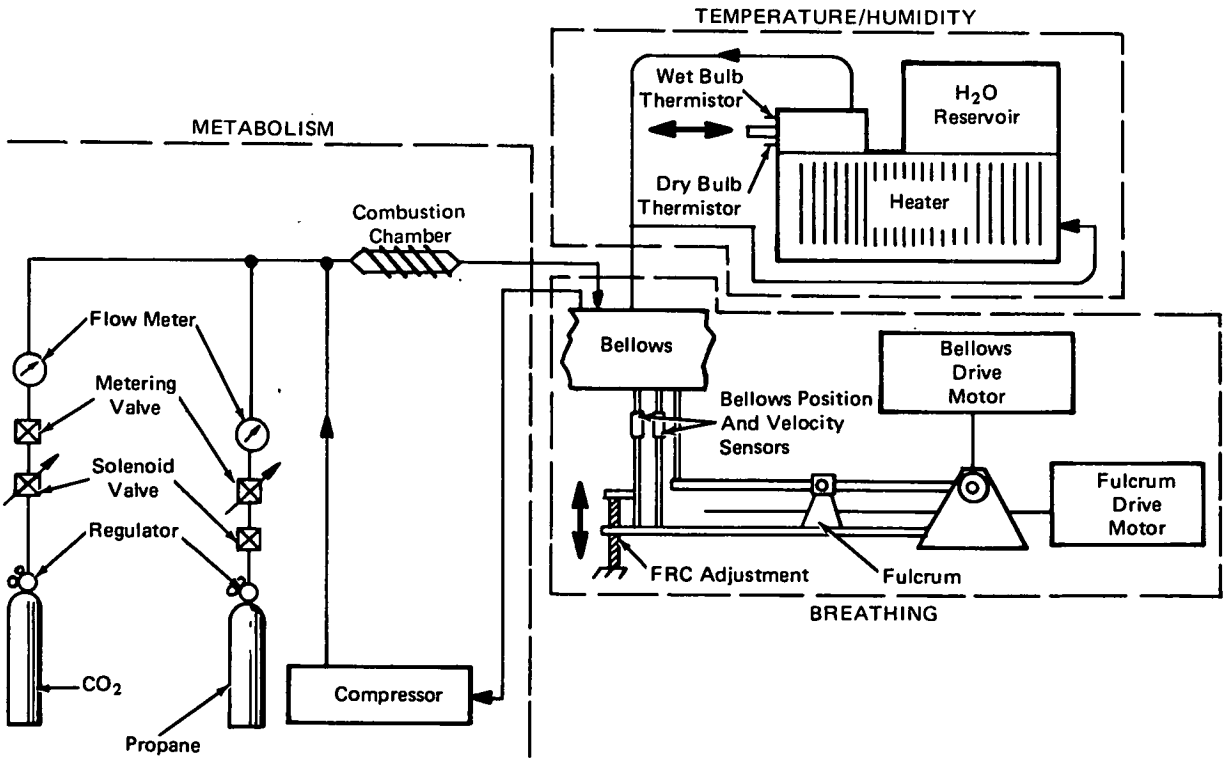
The solution:

A breathing-metabolic simulator has been developed to be used for evaluation of life support equipment.

How it's done:

The apparatus, as shown in the figure, simulates human breathing rate and controls temperature and humidity of exhaled air as well as its chemical composition. All of these functions are designed to correspond to various degrees of human response.

The breathing rate in this system is maintained by bellows which are driven by a motor operating through the simulated breath mechanism. The motor speed is controlled by the simulated breath waveform control, which independently determines the rate and waveform pattern. Breath depth changes may be implemented remotely by energizing the fulcrum drive motor to vary



(continued overleaf)

the lever arm ratio in the drive mechanism. In addition, functional residual capacity (FRC) adjustment is accomplished by moving the fulcrum normal to the lever arm (i.e., moving the position of the bottom of the bellows for a fixed crank position and lever arm ratio).

Temperature and humidity of the breath exhaled from the bellows are adjusted by a humidification chamber where the temperature of exhaled air is raised to that of the human and moisture is added to obtain near saturation of the chamber output upon succeeding breaths. The temperature is provided by a heat sheet located in the bottom of the chamber. It is controlled by sensor at the chamber output. Humidification is accomplished by passing the breath to be exhaled over a large area of surgical sponge which wicks moisture from water covering the heater.

Exhaled breath composition corresponding to various metabolic rates is simulated by varying the output breath CO_2/O_2 ratio (R). Oxygen is consumed and CO_2 produced to obtain various ratios by oxidizing propane gas fed from a storage cylinder after combination with compressed air gathered from the bellows. (Addition of CO_2 from storage allows rate changes.) This oxidation process occurs in a combustion chamber where the propane is heated above its ignition temperature. The gas is then cooled and returned to the bellows where it mixes with incoming air to form the proper output "R" value.

The breathing metabolic simulator has several unique features:

1. The combination of breathing and metabolic simulation in the same simulator permits more comprehensive testing of breathing equipment in that the simulation is much more realistic than could be obtained before.
2. Separate packaging for the control unit and for the simulator unit itself permits testing of breathing devices in hostile environments and allows changes in value of test parameters to be accomplished without interruption of the test conditions.
3. Continuously and independently variable rates for both breathing and metabolic parameters permit selection of an infinite number of simulated loadings within the wide range of the simulator capabilities.

Notes:

1. Additional information is contained in the following Tech Briefs: B72-10658 (HQN-10776), B72-10659 (HQN-10777), B72-10660 (HQN-10778), and B72-10661 (HQN-10779).
2. Requests for further information may be directed to:
   Technology Utilization Officer
   NASA Headquarters
   Code KT
   Washington, D. C. 20546
   Reference: B72-10657

Patent status:

NASA has decided not to apply for a patent.

Source: R. G. Bartlett, C. M. Hendricks, and W. B. Morison of IBM Corp. under contract to NASA Headquarters (HQN-10766)