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EVALUATION OF THE SIERRA, HANGING, QUICK-DON, CREW, PRESSURE-BREATHING, OXYGEN MASK

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I. Introduction.

Since the introduction of jet transports certified to operate at altitudes up to 41,000 feet, there have been numerous changes and modifications of crew oxygen masks in an attempt to provide better comfort, protection, and donning capability. Most of the early jet-transport quick-don oxygen masks were designed to be worn by crew members somewhat as personal items of equipment that could be rapidly donned in the event of a decompression. Crew resistance and maintenance problems associated with these masks have fostered the development of the hanging quick-don crew oxygen mask, which is regarded in some cases as a cockpit item. It is not the purpose of this paper to compare the merits and deficiencies of these two systems. The primary objective is rather to determine the physiological adequacy and protective efficiency of a new hanging quick-don oxygen mask design at altitude and during rapid decompression. This should precede its installation in aircraft. Other related parameters, including comfort, crew member performance, communication, and mask-donning capability, were evaluated.

The evaluation was performed in three phases. The first phase consisted of exposing crew members to a chamber flight profile as shown in figure A1, with a maximum altitude of 43,000 feet while wearing the mask. The second phase consisted of rapidly decompressing crew members from 8,000 to 40,000 feet in 45 to 50 seconds while wearing the mask. The third phase consisted of rapidly decompressing these same subjects from 8,000 to 40,000 feet in 45 to 50 seconds and donning the mask during the decompression. The donning signal was delayed for 15 seconds after passing through 14,000 feet during the decompression.

Since the subjects were well aware that they were to be decompressed, the basic 15-second delay was adopted after studying Bennett's[1] inflight determinations of the reaction and donning time of 42 BOAC pilots subjected to surprise decompressions during training flights. It was anticipated that trained subjects would require approximately 5 seconds to accomplish donning following the donning signal. This would result in a total donning delay of approximately 20 seconds after passing through 14,000 feet. An analysis of Bennett's data by Blockley[2] indicates that 99% of the pilots would have completed donning within this time period. Time-motion analysis of motion picture films taken during these decompressions shows that crew members accomplished mask donning in an average time of 4.80 seconds with a range of 2.5 to 6.29 seconds. These data are in general agreement with the data of Barron and Cook[3] who stated that their trained subjects required a minimum of 3 to 4 seconds to accomplish donning.

II. Methods.

The first phase of the evaluation was based on the chamber flight profile as shown in Figure 1. Five subjects were used in these evaluations. Three of the subjects were transport pilots, one a flight engineer student pilot, and the fifth subject a chamber research technician student pilot.

After instrumentation, the subject was seated in the chamber at the controls of a performance-testing device to be described later. An ascent to 10,000 feet followed by a descent to 5,000 feet was performed to assure ear-clearance capability. The mask was then donned and the subject placed on 100% oxygen. Denitrogenation was thereby initiated and allowed to continue for approximately 30 minutes at 5,000 feet. During denitrogenation various instrumentation checks and calibrations were performed. The subject was instrumented as shown in Figure A2. A Custom Engineering and Development 300 AR nitrogen analyzer continuously sampled gas from the mask through a 0.03-inch-diameter microcatheter tubing. The inspired tracheal-oxygen partial pressure is calculated from the following equation:

$$P_{T_{O_2}} = (B-47)F_{I_{O_2}}$$

Where

B = Ambient barometric pressure
47 = Vapor pressure of H_2O at body temperature (37°C) and 100% saturation

$F_{I_{O_2}} = 1.0 - F_{I_{N_2}}$

The 0.03% CO_2 in the ambient air is negligible and may be disregarded.

Pressure-breathing characteristics of regulators are given in Table B1 (all tables are in Appendix B). A Technology Inc. Model MFM-150-1 mass flowmeter was interposed in the supply hose between the regulator and the mask. A Statham pressure transducer of ±15 mm range was connected through an orifice in the mask. Telemedics EKG electrodes were carefully located to produce a maximal signal with a minimum of muscle-potential interference. The signal was split and fed into a Waters Cardiotachometer and an EKG monitoring oscilloscope. All signals were fed into a 14-channel visicorder for direct read-out. Nitrogen analyzers provide a convenient method of quantitatively determining the extent of inboard leakage of air and the resultant dilution of inspired oxygen, providing the subject has previously completed respiratory-nitrogen washout.

The mass-flowmeter signal was fed into an integrator so that, after a specified volume had been sensed, the unit would discharge and repeat. This was set at one liter NTPD. Therefore, all volumes required correction for chamber pressure, temperature, and saturation. The minute volume was recorded in terms of NTPD and converted to ATPD and BTPS conditions. The minute volume was not necessarily a true respiratory minute volume but rather a measure of the inspired-oxygen volume flowing to the subject upon demand or pressure. It is obvious that inboard or outboard leakage at the mask algebraically influences this measurement. Provisions for estimating inboard and outboard leakage were included in the experimental design allowing for correction of the minute volume when warranted.

Inboard leakage may be determined by measuring the amount of nitrogen-containing ambient air (a convenient reference gas) entering the mask when the subject has completed respiratory nitrogen washout while breathing 100% oxygen. Outboard leakage can be detected and estimated during pressure breathing by observing and measuring the slope of the mass-flowmeter record during the respiratory pause and exhalation. During the respiratory pause and exhalation, the mass-flowmeter record should be flat.

Outboard leakage is indicated in Figure A3 during pressure breathing. It was outstanding during the first and second minutes, but ceased at the end of the second minute. An estimate of the volume of leakage may be obtained by measuring the mean slope of the flowmeter recording during respiratory pause. Leakage may fluctuate during expiration and inspiration. Motion pictures were taken at maximum altitude and during rapid decompression. Closed-circuit television was used to monitor the subject's activity during the flight.

The minute volume, more accurately designated $M\dot{V}_I$ in accordance with standardized symbols,[4] was divided by the respiratory frequency (f) to obtain the mean tidal volume ($\overline{TV}$), i.e.:

$$\overline{TV} = \frac{M\dot{V}_I}{f}$$

where:

$M\dot{V}_I$ = volume of gas inspired/minute
$\overline{TV}$ = mean volume of gas inspired per breath
f = respiratory frequency or number of breaths per minute
$-$ = indicates a mean value
$\dot{V}$ = gas volume per unit of time

Individual tidal volumes may also be read from the mass-flowmeter recording.

The second phase utilized a profile that consisted of an ear check and a dwell time of 25 to 30 minutes at 8,000 feet to complete denitrogenation. The subject was then rapidly decompressed from 8,000 to 40,000 feet in 45 to 50 seconds while wearing the mask. Instrumentation was similar to that used in the first phase with the exception that an ear oximeter and impedance pneumograph were added. In addition, an experimental blood pressure device was also utilized (Figure A4).

The output of the Waters ear oximeter was fed into an Electronics for Medicine amplifier, displayed on a panel meter and oscilloscope and also fed into one of the two direct readout visicorders. The impedance pneumograph signal was amplified by a Physiograph and also recorded on one of the visicorders.

In the third phase, four of the subjects were exposed to a profile similar to that of the second phase with the exception that the mask was removed after 25 to 28 minutes of denitrogenation and the subjects breathed air at 8,000 feet for two minutes. A fifth subject was rapidly decompressed from 8,000 to 40,000 feet without any previous denitrogenation.

Prior to the decompression and during the time the subject was breathing air, the chamber safety observer would hang the mask back up in its retention device. During the decompression, as the chamber passed through 14,000 feet, an audible alarm bell alerted the subject. Fifteen seconds later and at approximately 25,000 feet, a red donning signal light was activated and the subject donned the mask. Read-out of the mass-flowmeter and mask-pressure-transducer data indicated the subject's completed mask donning at an altitude of 28,000 to 31,000 feet during decompression.

In Phase One, a standard sentence was repeated on command during normal and pressure breathing, monitored and recorded for subjective evaluation of intelligibility. Also, in the first phase, the donning ability of the mask by a hypoxic subject was to be evaluated at a level-off altitude of 30,000 feet during descent. The mask was to be removed at this altitude for a period of time until hypoxia became evident and redonned before useful consciousness was lost.

Two of the subjects utilizing regulators incorporating the commercial pressure-breathing schedule did not appear to possess adequate physiological well-being at 43,000 feet, and this portion of the evaluation was cancelled. Symptoms of severe hypoxia developed in these two subjects after 1 to 1-½ minutes dwell time at 43,000 feet, and an emergency descent to ground level was simultaneously ordered by the researcher and the attending flight surgeon. The failure of the subjects to complete the preprogrammed flight profile at 43,000 feet was not attributed to any defect in the regulator, but rather to the lower pressure-breathing schedule of the commercial pressure regulator. The fact that the commercial regulator did produce pressures in the mask within the range specified for commercial regulators (Table 1) was verified by intramask pressure measurements (Table B2).

The average tracheal-oxygen partial pressure 82.5 mm) of the three subjects utlizing the commercial pressure-breathing regulator schedule at an altitude of 43,000 feet is marginal and is not considered to be adequate to maintain the subject in a satisfactory physiological condition at 43,000 feet.

Since minor variations in the tracheal-oxygen partial pressure at 43,000 feet can produce significant changes in physiological well-being, the average tracheal-oxygen partial pressure (86.5 mm) of the two subjects utilizing the military pressure-breathing schedule was sufficient to allow them to complete the preprogrammed altitude profile satisfactorily.

One experienced chamber technician, utilizing a commercial pressure-breathing regulator, successfully completed the donning evaluation at 30,000 feet. His mask removal time was, however, much shorter than the subjects using the military pressure schedule (Figures A5, A6, and A7).

An evaluation of crew-member performance when wearing the mask at various pressure-breathing altitudes up to 43,000 feet was performed in the initial evaluation as follows:

Each subject was trained on the Scow complex coordinator. This device was originally designed by Mashburn and subsequently modified by Dr. Jim Scow. The apparatus consists of two manual and two pedal response controls. The subject's task is to effect a match or solution to a stimulus pattern of four lights, employing the four response controls. The display panel is divided into four quadrants, each quadrant containing a vertical row of five stimulus lights and a parallel row of five response lights. Positioning of the appropriate pedal or manual control lights a single response light. A trial is successfully completed only when all four of the controls are concurrently positioned correctly. At the base of the display panel is a timer which can be preset at any interval up to 15 seconds. The timer automatically resets when each problem is successfully completed. If a subject does not complete the problem in the preset time, two large red lights immediately forward of the manual controls are activated and remain on until the subject successfully completes the problem. The sweeping red hand of the timer followed by the appearance of the red lights serves to act as a motivation factor. As each problem is successfully completed, a programming drum moves one step and presents a new problem to the subject. Each of these steps represents a trial, and 25 trials represent a cycle or block. Responses are recorded by means of an Esterline Angus event recorder, while a counterprinter yields the time to complete a cycle or block in minutes and hundredths of a minute. The shorter the block time, the higher the rate of performance.

III. Results.

Readout of all data was accomplished at each altitude or when a significant event occurred.

A. Phase One—Chamber Flight to 43,000 Feet. Data obtained in the first phase are shown in Tables B2, B3, and B4. The upper record in Figure A8 was obtained on a subject using a commercial regulator at 43,000 feet. The lower record was similarly recorded at 43,000 feet utilizing a military pressure-breathing regulator. Oxygen regulators incorporating the commercial pressure schedule did not provide adequate pressure to maintain the subjects in a satisfactory physiological state at 43,000 feet. Military regulators with higher pressure schedules appear to supply sufficient pressure. It should be pointed out that in this instance the regulator pressure schedule and not the mask was deficient.

Physiological response and mask performance are shown in Tables B2, B3, and B4. As would be expected, minute volume, mean tidal volume, and heart rate reached their maximum values at a pressure-breathing altitude of 43,000 feet. Heart rates increased steadily following mask removal and decreased to normal within one minute following redonning of the mask, a normal response to the stress induced by hypoxia and recovery. Records of the three subjects who completed the mask removal experiment at 30,000 feet are reproduced in Figures A5, A6, and A7.

Results of the subjective speech-intelligibility evaluation and coordinator performance are presented in Table B5.

Since operation of the complex coordination task requires higher cerebral function, it is not surprising that performance fell off when subjects were utilizing the lower pressure schedule of the commercial regulator or performing the mask-removal—hypoxia experiment at 30,000 feet. One of the principal values of using the complex coordinator was that it kept the subject occupied with a task requiring mental and motor coordination analogous to the demands of piloting an aircraft.

Two versions of the mask suspensions system were used during these evaluations, one being fabricated from plastic and the other of aluminium. It was the investigators' subjective evaluation that the aluminum alloy suspension system was more rigid and retained its shape for donning over earphones and glasses more readily than the plastic version.

The pressure-breathing characteristics and tolerances of typical dilutor-demand pressure breathing commercial and military oxygen regulators are presented in Table B1. These values may be compared to the actual pressures obtained in Figure A8.

It may be noted that minor concentrations of nitrogen were detected in the breathing hose from the military schedule regulator with the regulator control positioned in the 100% oxygen position. Tests were conducted at ground level to attempt to isolate the source of the nitrogen. Initially, the 21-gauge hypodermic sampling needle was inserted downstream from the mass flowmeter in the breathing hose to the mask. It was removed and inserted upstream from the flowmeter at the junction of the hose and outflow of the regulator. This arrangement was tested repeatedly, and, although the nitrogen apparently coming from the regulator was reduced, it was not eliminated. It was thought that very minute quantities of nitrogen might be entering by way of a defective seat in the ambient-air dilution shutoff. Occasionally, nitrogen concentration in the supply exceeded that in the mask (Table B3). Possibly, incomplete mixing at the leaking regulator of oxygen and air could be responsible. In any event, this military schedule regulator was removed and replaced with a new military regulator. The defective military regulator was not detected and replaced until the second phase of the evaluations was completed. It was also found that a subject breathing air and then donning the mask would induce a minor increase in nitrogen in the breathing hose. It could be demonstrated repeatedly that the intrahose nitrogen decreased as the mask nitrogen decreased during respiratory washout. It appeared therefore that the pressure compensating valve in the mask was allowing a minor amount of gas in the mask to enter the breathing hose. Concentrations encountered, however, are minor, never exceeding 4% and in most instances no more than 1%.

B. Second Phase—Rapid Decompression Wearing the Mask. Subjects instrumented as shown in Figure A4 were exposed to a rapid decompression from 8,000 to 40,000 feet as previously described. Records of these decompressions are reproduced in Figure A8 to A12. The upper record includes the ear-oximetry trace (labelled S), altitude (A), mass-flowmeter volume (V), and mask pressure (P). The lower record includes the electrocardiogram (EKG), cardiotachogram (C), and impedance pneumogram (I). In addition, an experimental evaluation of a method of rapidly determining blood pressure during decompresion was included in the second and third phase decompressions.

Since this was an experimental physiological procedure that was conducted primarily to test and develop the procedure per se and was not essential to the evaluation of the mask, it will not be discussed in this paper but will be reported separately at a later date.

The impedance pneumogram exhibited varied responses to decompression as shown in Table B6. Four of the subjects exhibited considerable increase in amplitude and one subject showed a baseline shift and little or no increase in amplitude. The impedance pneumogram factor in Table B6 is the ratio by which the amplitude varies from the baseline amplitude that had been established as unity for each subject at 8,000 feet breathing oxygen prior to the decompression.

Electrocardiograph electrodes were also a problem. The type of electrodes used had previously proven satisfactory in exercise and other rather severe applications. In these chamber flights, conduction was occasionally erratic, with a tendency for this to occur more frequently during and following decompression. Since the ECG and cardiotachometer utilize common electrodes, a defect in the ECG results in an erratic nonreadable instantaneous heart-rate record. This problem was subsequently traced to chemical erosion of the electrodes, which made them subject to poor electrical contact during body movement. The bucking voltage utilized in the mass flowmeter drifted out of balance due to a faulty electronic component resulting in a downward or negative trend (trace V in Figure A13) and indicated an unrealistic minute and tidal volume during decompression for subject J. Se. (Table B6).

Blood-oxygen saturation as indicated by ear oximetry did not show any significant transient dips during decompression. Tracheal-oxygen partial pressures were also considered adequate (Table B7).

Significant outboard mask leakage was detected in one subject during pressure breathing at 40,000 feet. The leakage ceased at the end of the second minute at 40,000 feet. The extent of leakage may be estimated by noting the slope of the volume recording during the respiratory pause in Figure A3. The degree of heart-rate elevation was not remarkable (Table B8).

C. Third Phase—Rapid Decompression and Donning the Mask. Subjects instrumented as in the second phase (Figure A4) were rapidly decompressed from 8,000 to 40,000 feet in 40 to 45 seconds. Subjects had been breathing air for 2 minutes at 8,000 feet prior to decompression. The subjects received a mask donning signal 15 seconds after passing through 14,000 feet. The altitude at which subjects completed mask donning varied between 28,000 to 31,000 feet.

Records of the decompressions are reproduced in Figures A16 to A20. Four of the subjects were decompressed following 25 to 28 minutes of denitrogenation and 2 minutes of breathing air. The fifth subject was decompressed without previous denitrogenation. Initiation of the first breath following completion of donning may be obtained by examination of the mask-pressure and mass-flowmeter recordings. Occasionally, a sharp upturn in the mass-flowmeter recording shortly before initiation of the first breath may be observed. This merely indicates that the necessary altitude (27,000 to 32,000 feet) had been attained to activate the automatic pressure-breathing characteristics of the regulator. The system then became free-flowing until the mask was donned.

Small high-frequency spikes in the mask-pressure record preceding the first breath appear to be a result of changes in mask pressure associated with donning and seating the mask to the face.

Blood saturation as indicated by ear oximetry exhibited a marked transient drop 6 to 12 seconds after mask donning, being even more pronounced in the subject who had not completed denitrogenation. The delay due to lung-ear circulation time as well as the delay in reestablishing an adequate alveolar and cerebral pO_2 as a result of nitrogen washout was anticipated. These factors have been intensively and separately investigated by Ernsting, Bryan, Luft, Donaldson, and Clamann and are discussed in detailed by Blockley and Hanifan.[2]

The impedance-pneumograph factor and heart rate increased dramatically following the mask donning during decompression. Data obtained during rapid decompression and delayed mask donning are summarized in Table B10, B11, and B12.

It is anticipated that crew-member protection may not be provided if decompression is very rapid, donning excessively delayed, or the terminal altitude and dwell time at altitude increased.[2] The conditions of this study approached the physiological limitations for which mask design cannot be expected to compensate. Other problems, such as the use of long breathing hoses, which prior to decompression may contain significant quantities of nitrogen and require excessive time for washout, may be largely eliminated by improved mask-mounted regulator design.

IV. Discussion.

In the first phase, the plastic and aluminum mask suspensions were evaluated.

In the second and third phases of the evaluation, the aluminum suspension equipped with the MBU5/P facepiece was used exclusively.

This military facepiece design incorporates a rather wide, flexible, and extensive inner facial seal, providing good pressure-breathing characteristics. The technique of donning the mask is illustrated in Figure A14. Training should emphasize the importance of applying sufficient force in Step 2 so that the telescoping cylinders are fully extended and the mask centered over the face as in Step 3. The tension is then relaxed and the mask allowed to seat on the face as shown in Step 4 of Figure A14. If the cylinders are not extended sufficiently and the mask is applied by dragging it downward across the face, the flexible MBU5/P facepiece will exhibit a tendency to roll up within the hardshell and produce extensive leakage and inadequate protection.

Subjects donning the mask during rapid decompression did not hurry their donning procedure excessively, but donned the mask with careful but rapid deliberation, aware that excessive delay due to fumbling or dropping of the mask could result in loss of consciousness.

The decompressions with mask donning on four of the subjects were not considered to be as realistic as desired, as, for reasons of safety, nonemployee crew-member subjects were denitrogenated prior to rapid decompression. This ruling was relaxed to some extent by allowing 2 minutes of air breathing prior to decompression in an attempt to allow reestablishment of normal air breathing concentrations of nitrogen in the lungs. Comparison of initial nitrogen washout at ground level with nitrogen washout during decompression following 2 minutes of air breathing in Figure A15 indicates that 2 minutes of air breathing may not have been a sufficient time.

Nitrogen-washout data obtained in a previous study of a hanging quick-donning crew oxygen mask are shown in Table B9. Subjects in these experiments were rapidly decompressed from 6,000 to 41,000 feet in 41 to 49 seconds without prior denitrogenation. The mean nitrogen-washout curve of these subjects is included in Figure A15 and falls midway between the mean washout curve established at ground level prior to decompression and the mean washout curve obtained during decompression following 2 minutes of air breathing. It is probable that the nitrogen-washout time of subjects used in this series of decompressions would have been in closer agreement with the previous decompressions if they had been breathing air exclusively prior to decompression.

V. Conclusions.

1. The Sierra Quick Don Oxygen Mask appears to provide adequate protection at 43,000 feet if it is utilized with a compatible and reliable pressure-breathing demand regulator, incorporating a pressure-breathing schedule that will provide sufficient pressure to meet physiological requirements.

2. Demand pressure-breathing oxygen regulators incorporating a commercial pressure schedule did not appear to provide sufficient tracheal-oxygen partial pressure to maintain subjects in a satisfactory physiological condition at 43,000 feet.

3. Inboard leakage during demand breathing and outboard leakage during pressure breathing were minimal in most instances. In the one instance where outboard leakage developed during pressure breathing at 40,000 feet, the record indicates that this leakage did not result in a reduction in mask pressure since there was no significant change in mask pressure when the leakage was corrected prior to initiation of the descent.

4. When worn prior to and during a decompression, the mask provided adequate protection and there was no indication of significant hypoxia.

5. When mask donning was accomplished in response to a signal 15 seconds after passing through 14,000 feet, during a 45-second rapid decompression from 8,000 to 40,000 feet, there was a marked transient drop in blood saturation without loss of useful consciousness.

6. Donning was readily accomplished with one hand during decompression in an average of 4.8 seconds. The suspension system is designed to provide good peripheral vision and allow donning over earphones and eye-glasses.

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APPENDIX A

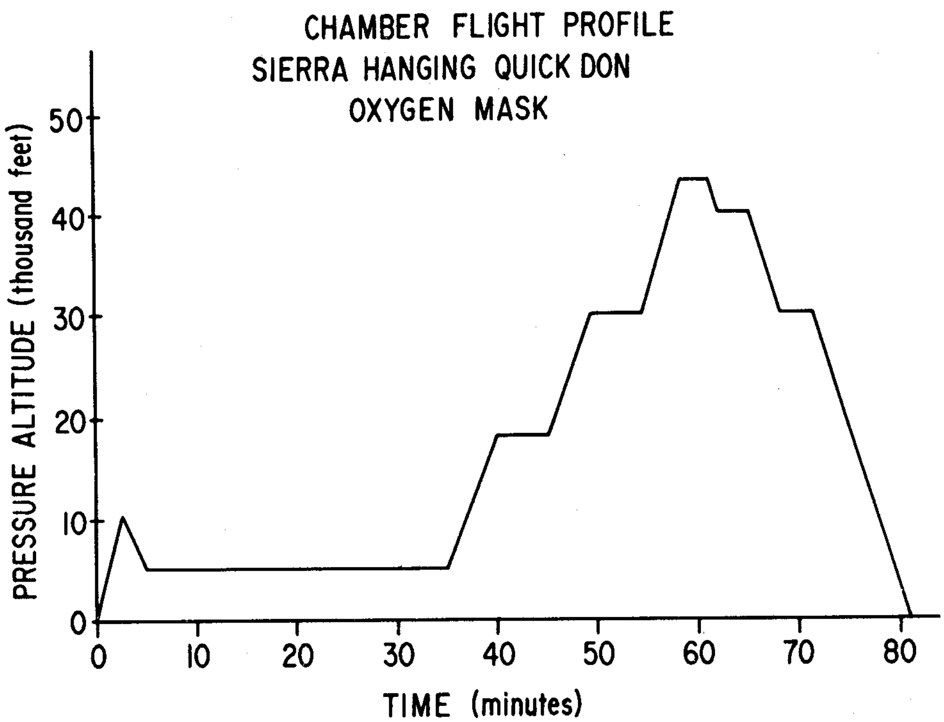

FIGURE A1. Altitude-chamber flight profile. Phase 1.

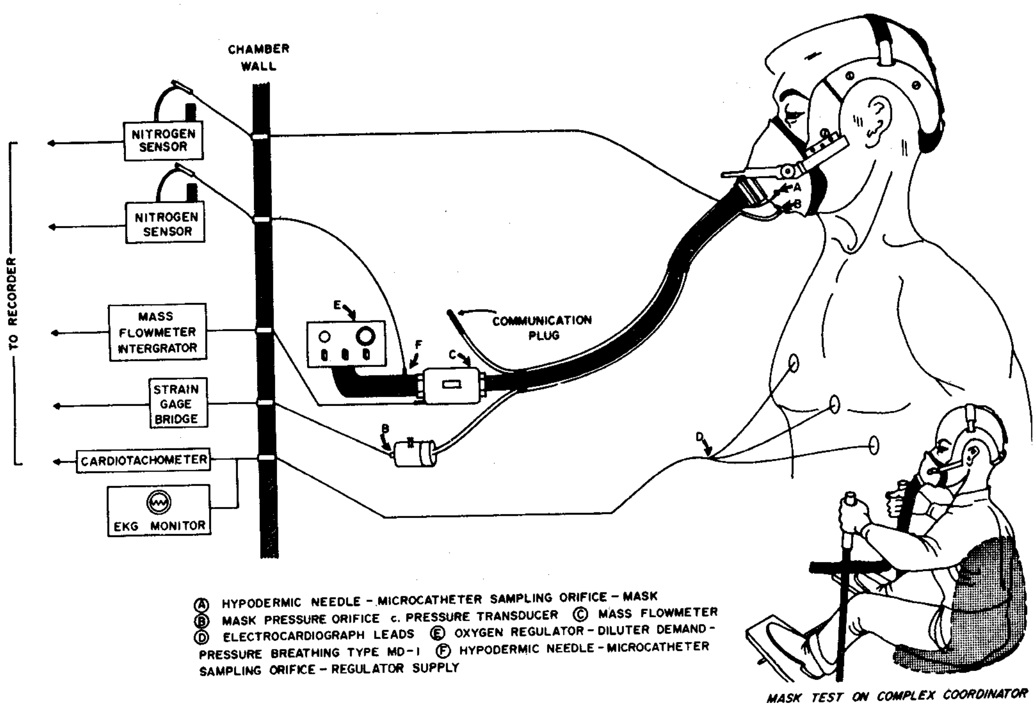

FIGURE A2. Instrumentation and activity of subjects during altitude-chamber flight. Phase 1.

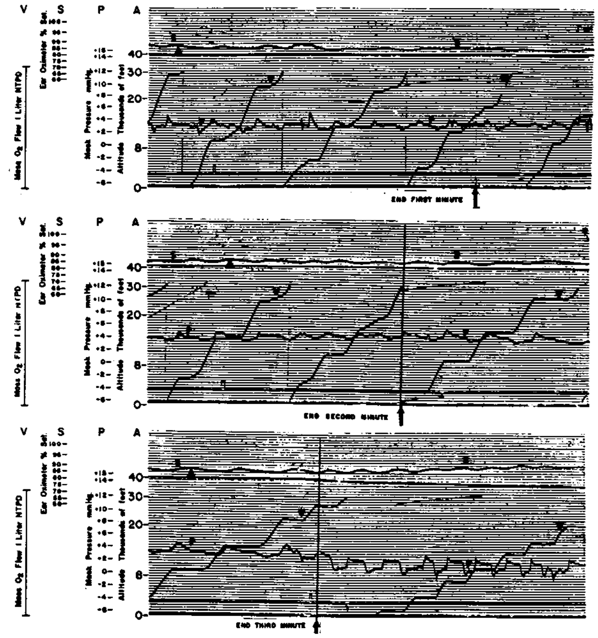

Figure A3. Reproduction of record indicating outboard leakage occurring up to the end of the second minute. Leakage may be estimated by determining the mean slope of the mass flowmeter (V) tracing during the respiratory pause and exhalation. Subject CPr.

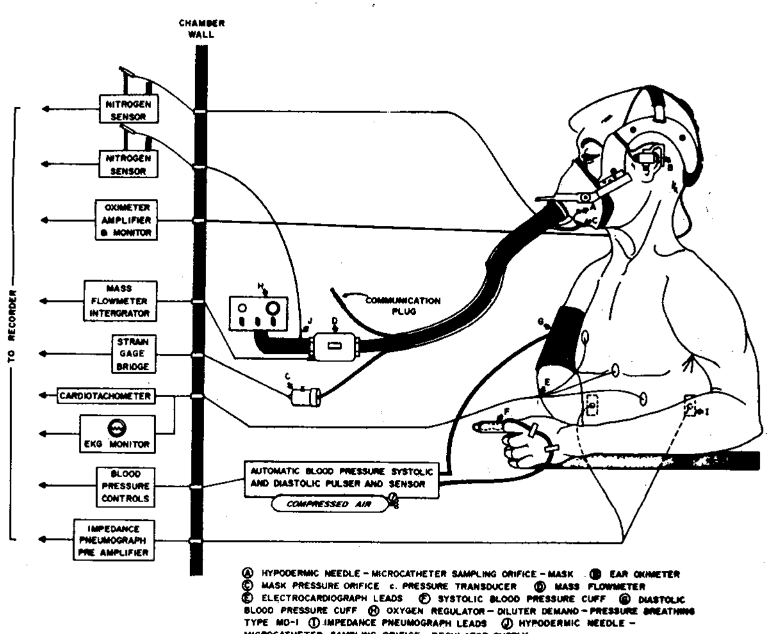

Figure A4. Instrumentation of subjects during rapid decompression from 8,000 to 40,000 feet. Ear oximetry, impedance pneumogram, and blood-pressure instrumentation were added for these experiments. Phase 2 and 3.

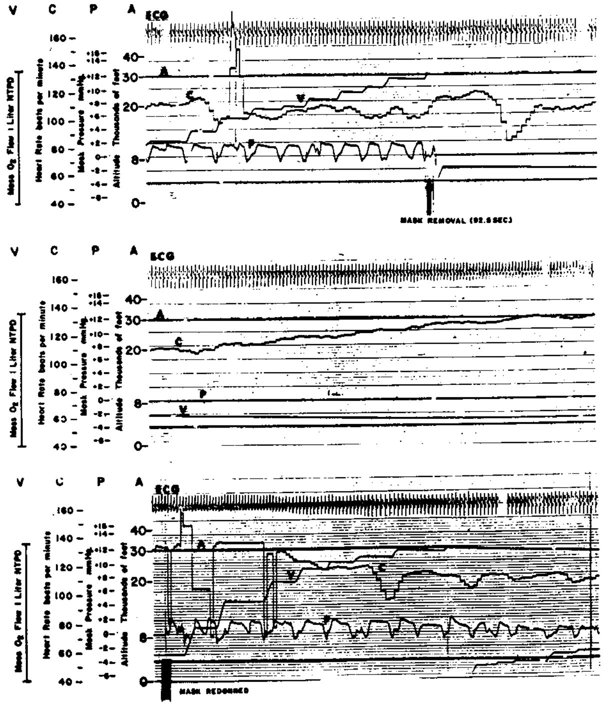

FIGURE A5. Mask removal and redonning at 30,000 ft. Subject BOr. Phase 1.

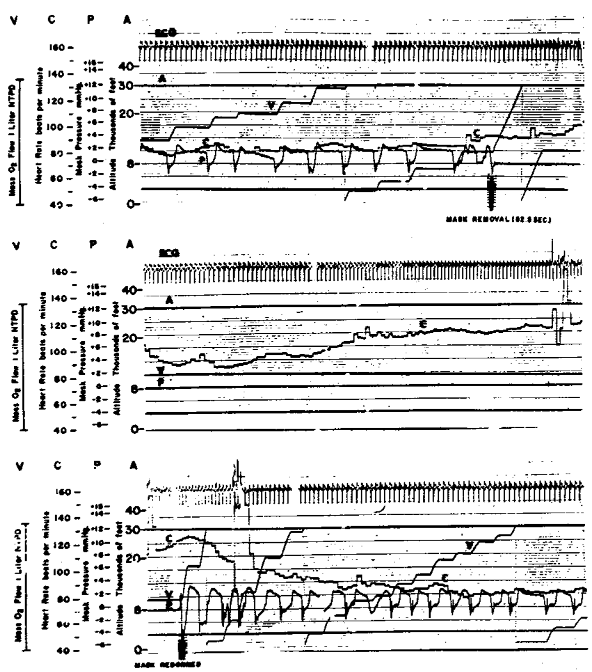

FIGURE A6. Mask removal and redonning at 30,000 ft. Subject CPr. Phase 1.

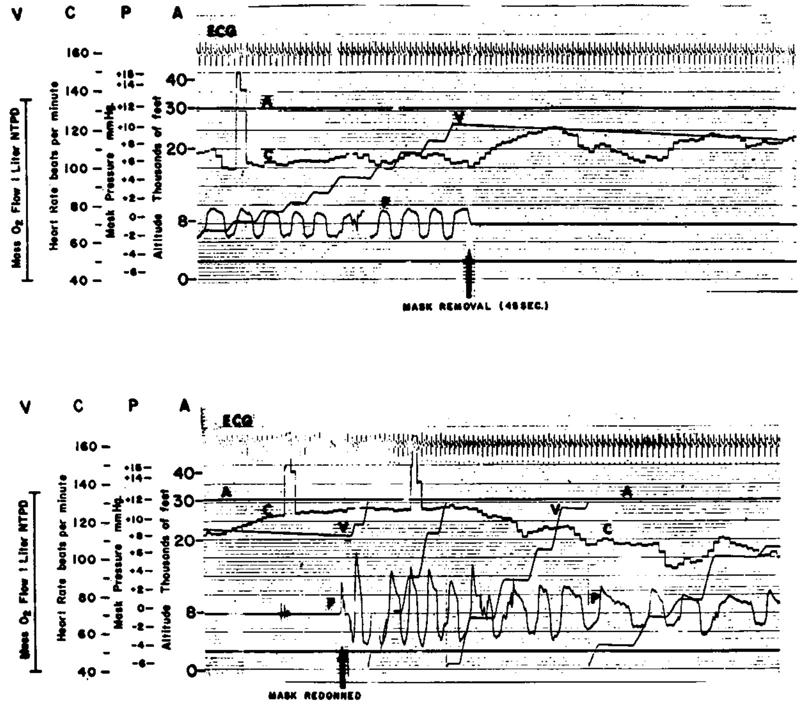

FIGURE A7. Mask removal and redonning at 30,000 ft. Subject JSi. Phase 1.

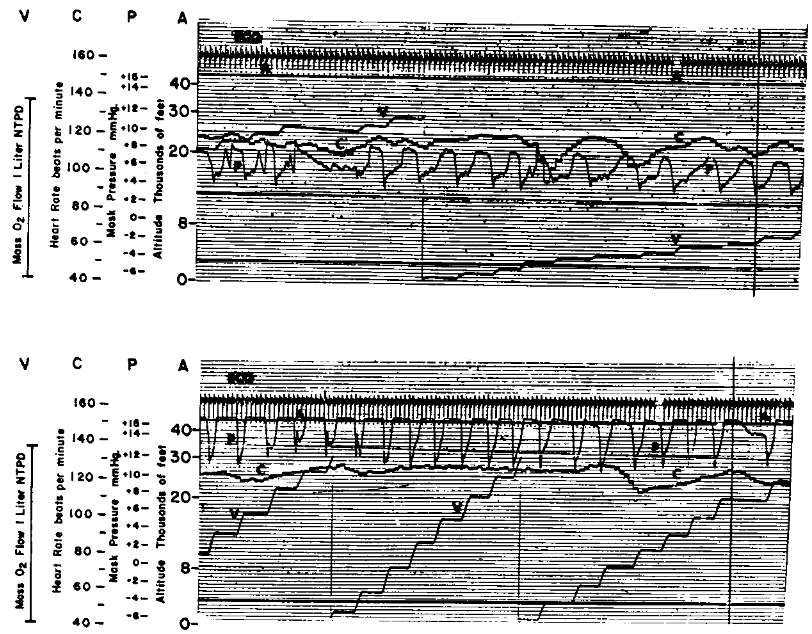

FIGURE A8. Comparison of mask pressure (P) at 43,000 feet as provided by commercial and military regulators. Upper record commercial pressure schedule. Lower record military pressure schedule.

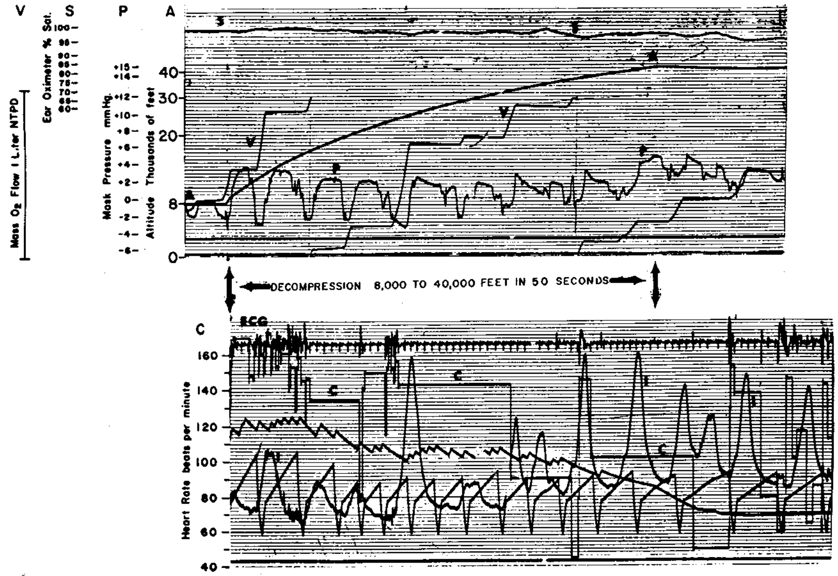

FIGURE A9. Rapid decompression wearing the mask. Subject CPu. I-Impedance pneumogram.

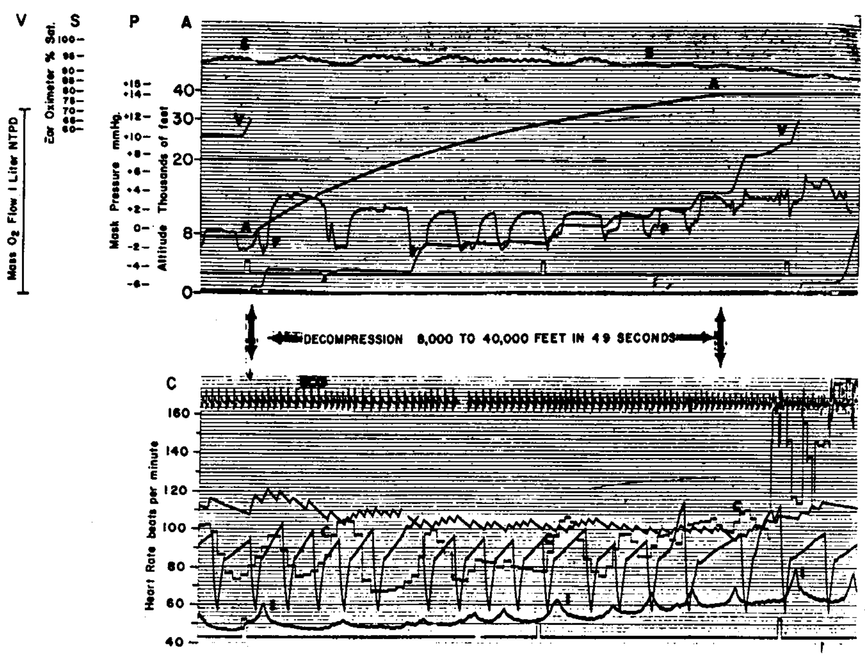

FIGURE A10. Rapid decompression wearing the mask. Subject CPr. I-Impedance Pneumogram.

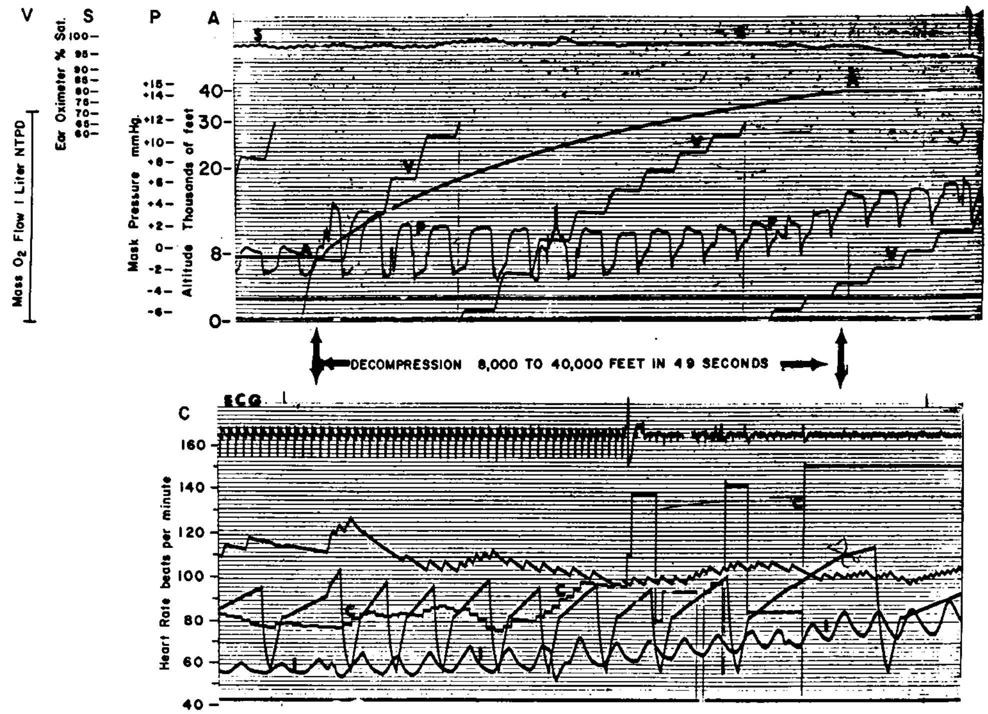

FIGURE A11. Rapid decompression wearing the mask. Subject BOr. I-impedance pneumogram.

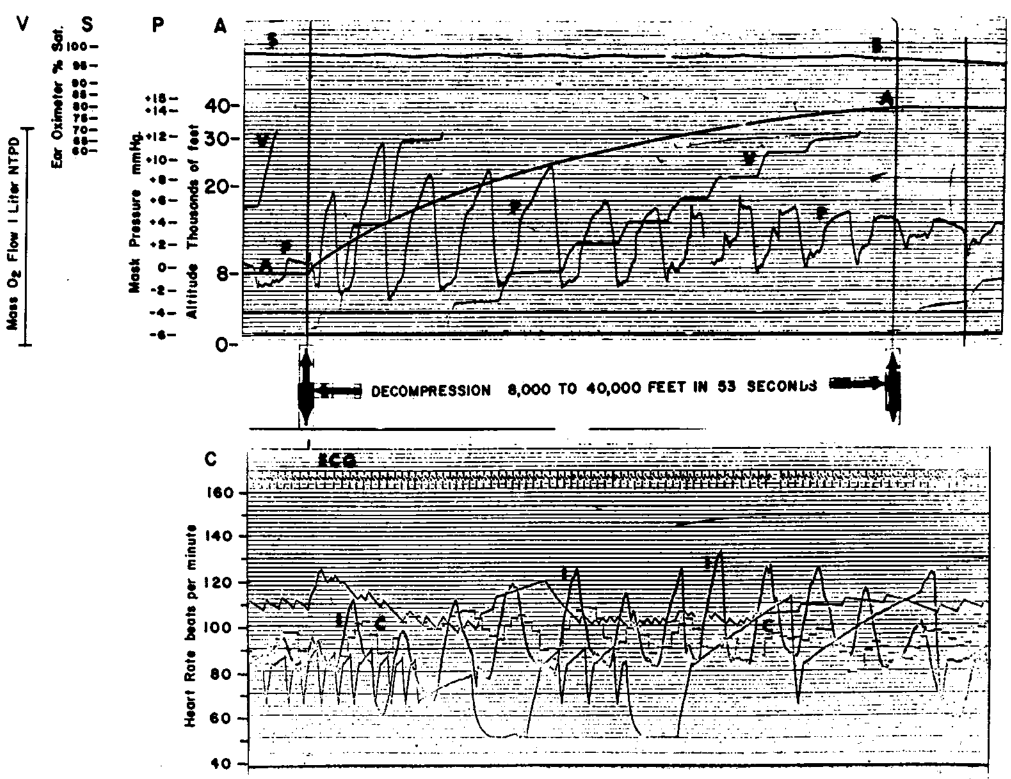

FIGURE A12. Rapid decompression wearing the mask. Subject JSi. I-Impedance pneumogram.

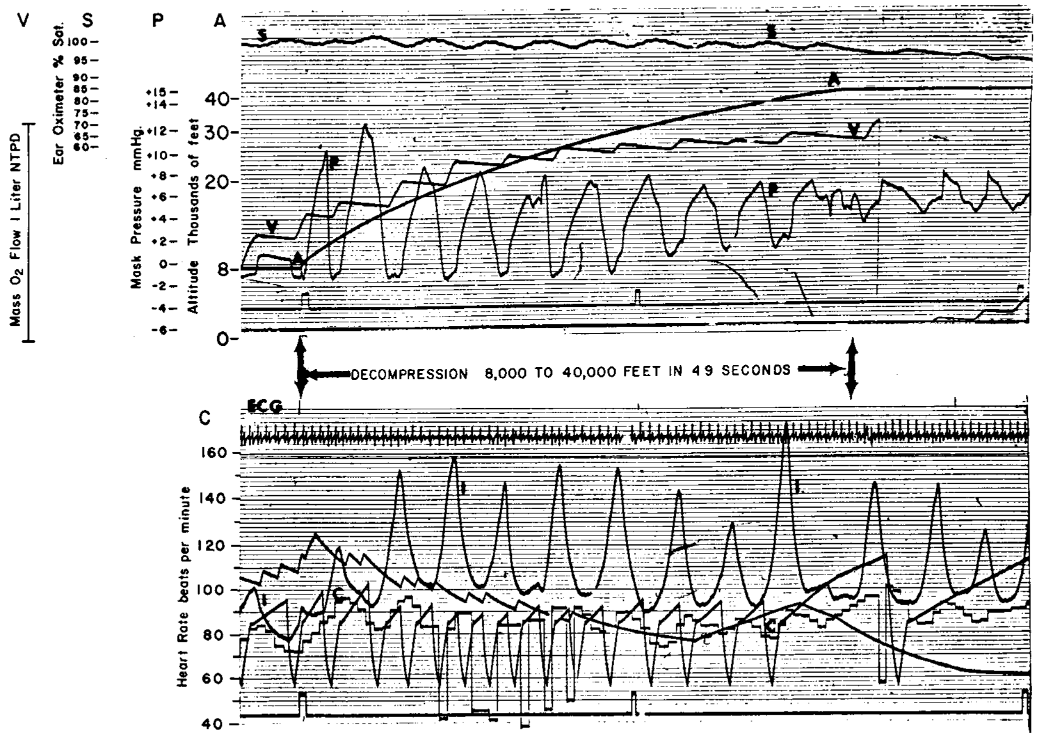

FIGURE A13. Rapid decompression wearing the mask. Subject JSe. I-Impedance pneumogram.

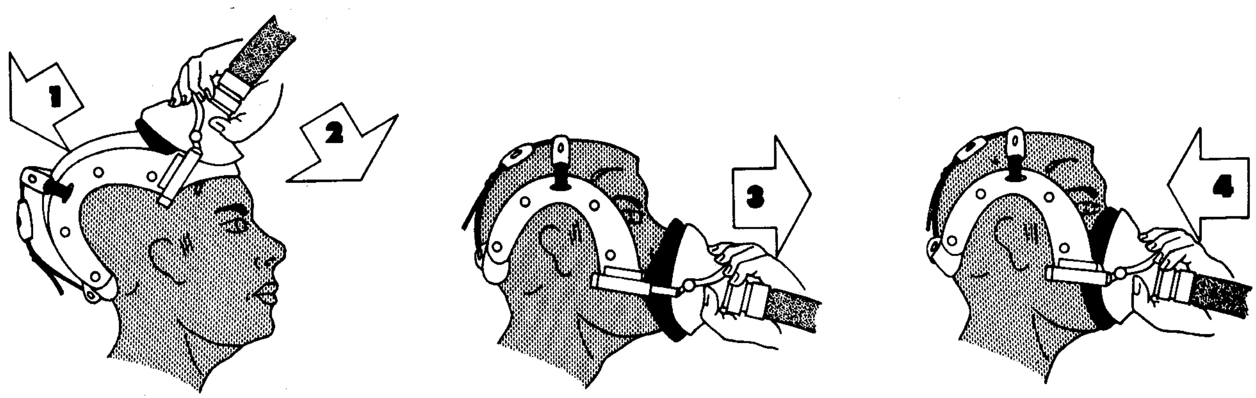

FIGURE A14. Mask-donning procedure. If equipped with the soft and flexible MBU5/P facepiece, sufficient tension should begin to be applied at position 2 so that the telescoping asembly is extended as the mask is brought down over the face to position 3. If allowed to drag over the face during this motion, the facepiece may be rolled up and distorted within the hardshell.

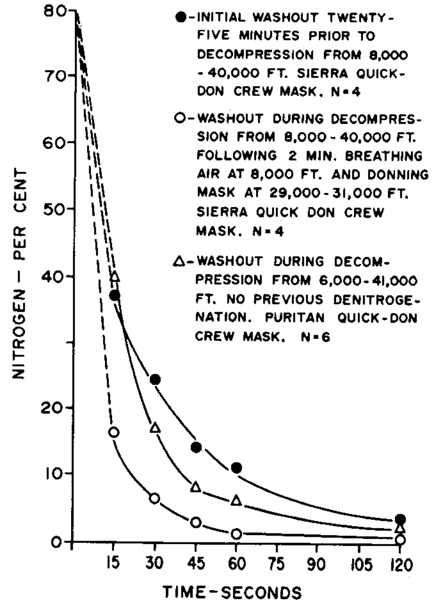

FIGURE A15. Comparison of initial nitrogen washouts prior to decompression with washouts during decompression after 2 minutes on air. The 2-minute air-breathing period followed an initial denitrogenation. The third curve was derived from unpublished data obtained in a previous crew-mask evaluation.

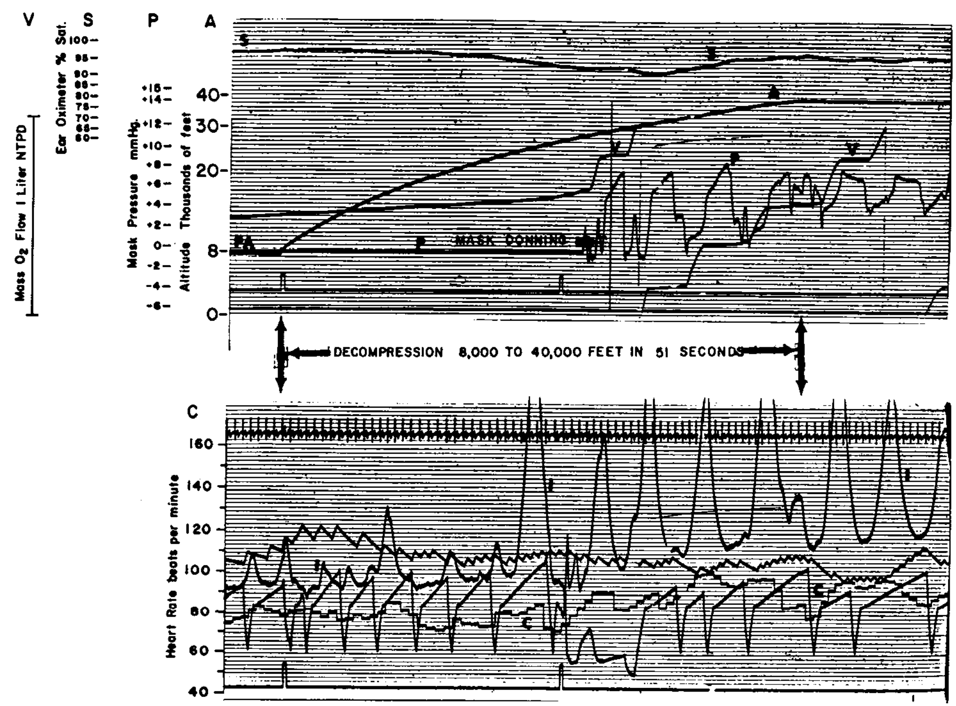

FIGURE A16. Mask donning during decompression. Subject CPu.

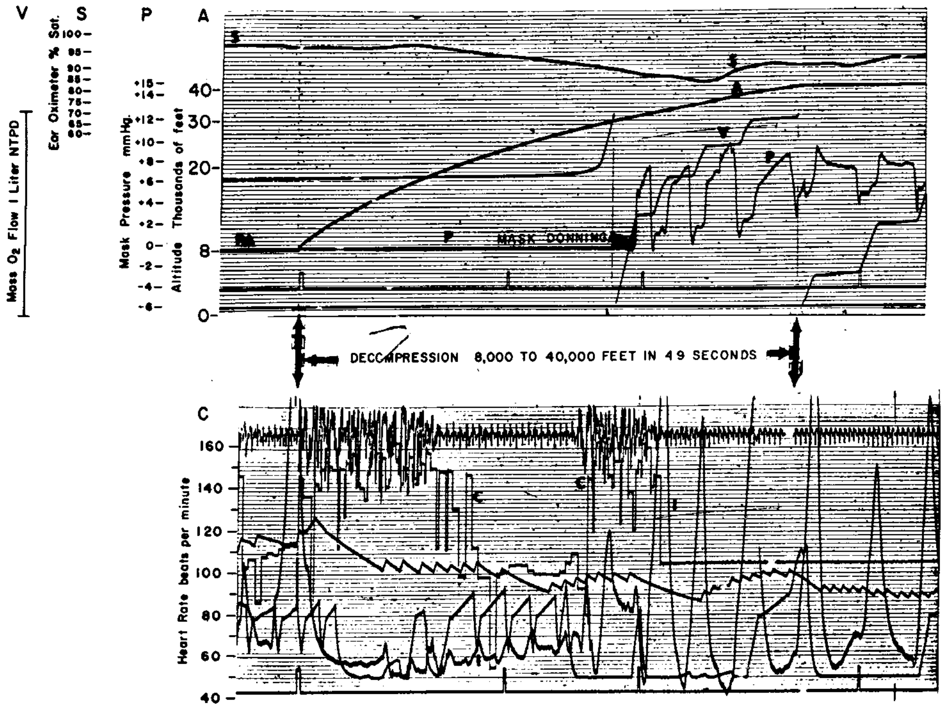

FIGURE A17. Mask donning during decompression. Subject CPr.

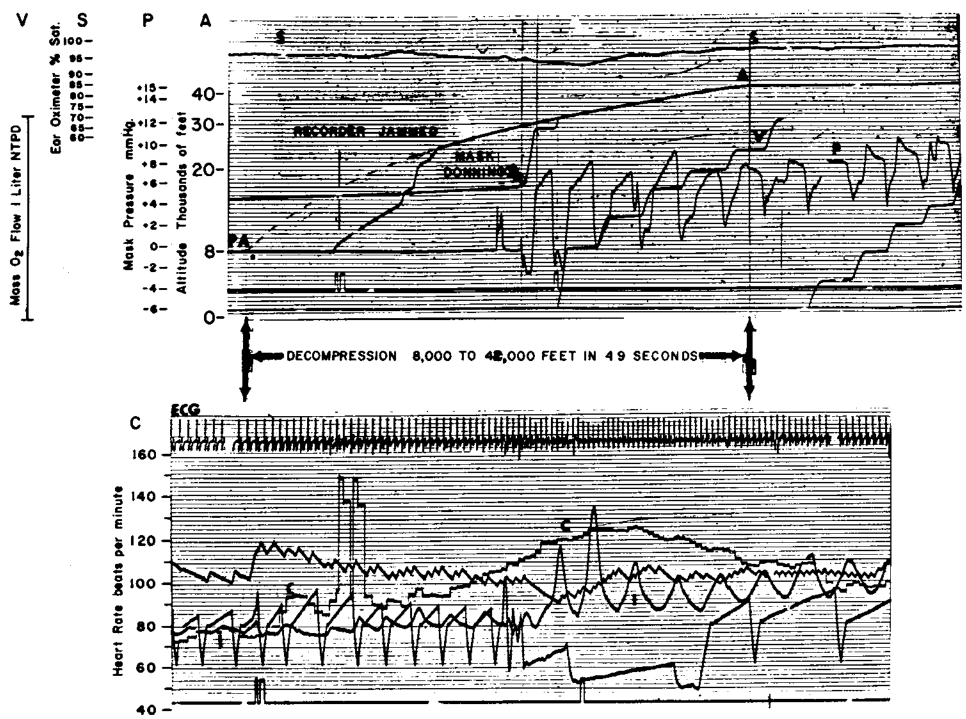

FIGURE A18. Mask donning during decompression. Subject BOr.

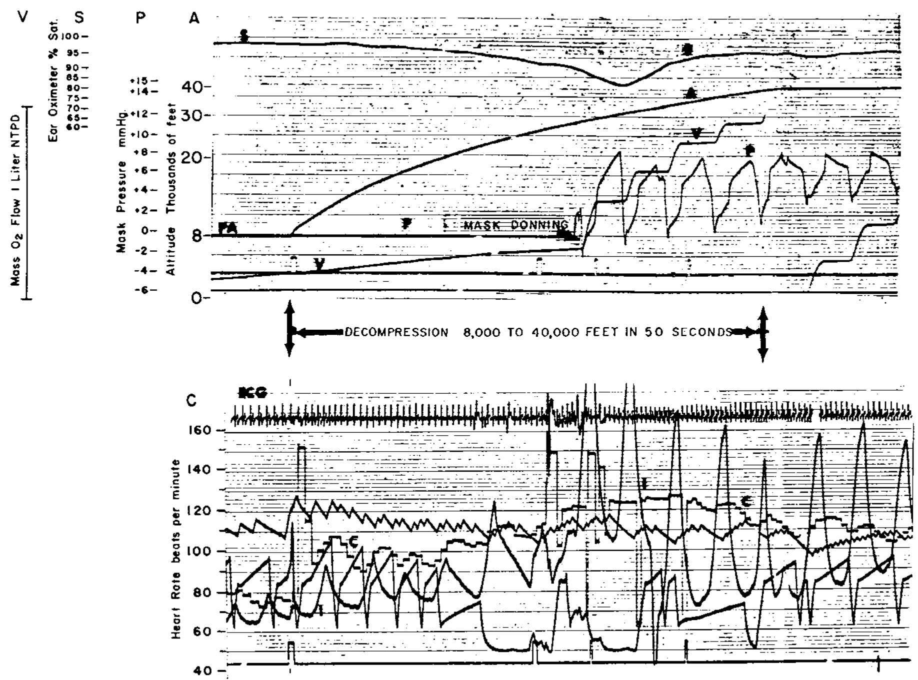

FIGURE A19. Mask donning during decompression. Subject JSe.

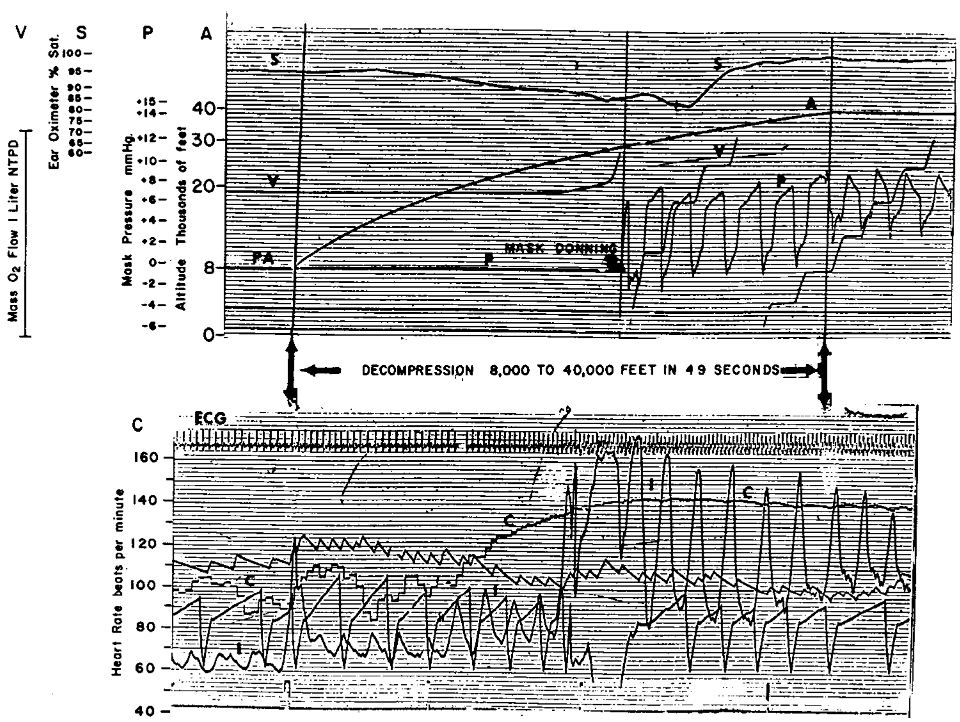

FIGURE A20. Mask donning during decompression. Subject EMc. No denitrogenation.

APPENDIX B

TABLE B1. Pressure Breathing Versus Altitude of Typical Commercial and Military Regulators.*

Altitude	Typical military regulator (in H_2O)	(mm Hg)	Typical commercial regulator (in. H_2O)	(mm Hg)
27,000	0.0– 1.0	0.0– 1.9	0.1–1.9	0.2– 3.5
29,000	0.0– 1.0	0.0– 1.9	0.1–3.2	0.2– 6.0
30,000	0.0– 2.5	0.0– 4.7	0.1–3.2	0.2– 6.0
32,000	0.0– 2.8	0.0– 5.2	0.1–3.2	0.2– 6.0
34,000	0.0– 3.0	0.0– 5.6	0.1–3.2	0.2– 6.0
36,000	0.0– 3.2	0.0– 6.0	0.1–3.2	0.2– 6.0
38.000	0.0– 3.4	0.0– 6.4	0.1–3.2	0.2– 6.0
39,000	0.3– 3.5	0.6– 6.5	0.1–4.7	0.2– 8.8
40,000	0.3– 5.6	0.6–10.5	0.7–4.7	1.3– 8.8
41,000	2.0– 7.2	3.7–13.5	2.2–4.7	4.1– 8.8
42,000	3.4– 8.6	6.4–16.1	2.2–7.2	4.1–13.4
43,000	5.3–10.2	9.9–19.1	4.7–7.2	8.8–13.4

* Personal communication R. K. Coulter, Chairman, SAE Committee A-10, Aircraft Oxygen Equipment.

TABLE B2. Ventilation Volume, Pressure and Frequency During a Step-Function Altitude Chamber Flight Profile to 43,000 Feet.

Subject and Condition	Altitude Feet	Barometric Pressure	Min. Vol. L/Min. ATPD	Min. Vol. L/Min. BTPS	Tidal Vol. cc. BTPS	Resp. Rate	Mask Pressure mm. Hg. Insp.	Exp.	Insp. Gas	
C. Pu.	5,000	632	6.26	7.10	444	16	-3.00	+ .50	O_2 100%	
Commercial	18,000	380	5.22	6.25	391	16	-2.00	+1.00	O_2 100%	
Pressure	30,000	226	7.75	10.34	574	18	-2.00	+1.00	O_2 100%	
Schedule	43,000	122	7.20	12.02	1,093	11	+5.00	+12.00	O_2 100%	
	40,000	141	8.32	13.09	1,190	11	±0.00	+4.00	O_2 100%	
No Mask Removal	30,000	226	6.27	8.36	697	12	-2.00	+2.00	O_2 100%	
	1,273	725	6.15	6.91	628	11	-2.00	+2.00	O_2 100%	
J. Se.	5,000	632	6.72	7.62	693	11	-3.00	+1.50	O_2 100%	
Commercial	18,000	380	5.70	6.81	524	13	-3.00	+1.50	O_2 100%	
Pressure	30,000	226	5.48	7.30	561	13	-2.00	+5.00	O_2 100%	
Schedule	43,000	122	7.50	12.51	658	19	+4.00	+13.50	O_2 100%	
	40,000	141	3.84	6.00	545	11	+1.00	+6.00	O_2 100%	
No Mask Removal	30,000	226	-----	-----	-----	--	-----	-----	O_2 100%	
	1,273	725	10.30	11.57	1,052	11	-4.00	+2.00	O_2 100%	
B. Or.	5,000	632	6.53	7.41	529	14	-2.50	+2.00	O_2 100%	
Military	18,000	380	5.70	6.81	358	19	-2.00	+1.50	O_2 100%	
Pressure	30,000	226	5.94	7.86	462	17	-2.00	+3.00	O_2 100%	
Schedule	43,000	122	14.64†	23.82†	1,254	19	+11.00	+15.00‡	O_2 100%	
	40,000	141	5.72	8.95	639	14	+2.50	+8.00	O_2 100%	
Just Prior to Mask Removal	30,000	226	4.39	5.81	484	12	-1.50	+3.00	O_2 100%	
Mask Removal 82.5 Sec	30,000	226	----Heart Rate Steady Increase From 82-125-----						Air	
Recovery	30,000	226	8.78	11.71	650	18	-4.00	+3.50	O_2 100%	≠
	1,273	725	9.00	10.11	919	11	-3.00	+2.50	O_2 100%	
C. Pr.	5,000	632	8.40	9.53	454	21	-3.00	+1.00	O_2 100%	
Military	18,000	380	6.12	7.33	407	18	-1.50	+1.00	O_2 100%	
Pressure	30,000	226	4.03	5.33	314	17	-1.00	+2.00	O_2 100%	
Schedule	43,000	122	6.00	9.83	1,229	8	+9.00	+15.00‡	O_2 100%	
	40,000	141	3.33	5.21	580	9	+2.00	+6.00	O_2 100%	
Mask Removal 92.5 Sec	30,000	226	----Heart Rate Steady Increase From 80-132 Off-Scale						Air	
Recovery	30,000	226	3.96	5.24	403	13	-1.00	+2.00	O_2 100%	φ
	1,273	725	7.66	8.60	573	15	-2.00	+1.50	O_2 100%	
J. Si.	1,273	725	9.47	10.63	818	13	-3.00	+2.50	O_2 100%	
Commercial	5,000	632	9.90	11.22	701	16	-3.00	+2.00	O_2 100%	
Pressure	18,000	380	7.22	8.64	576	15	-2.50	+2.00	O_2 100%	
Schedule	30,000	226	4.85	6.46	431	15	-2.00	+1.00	O_2 100%	
	43,000	122	3.84	6.41	458	14	+5.00	+9.00	O_2 100%	
	40,000	141	3.33	5.24	327	16	±0.00	+3.00	O_2 100%	
Mask Removal 45.0 Sec	30,000	226	----Heart Rate Steady Increase From 96-120-----						Air	
Recovery	30,000	226	11.09	14.78	821	18	-3.00	+3.00	O_2 100%	π
	1,273	725	9.64	10.82	901	12	-3.00	+2.50	O_2 100%	
MEAN:	5,000	632	7.56	8.58	564.2	15.6	-2.90	+1.40		
	18,000	380	5.99	7.17	451.2	16.2	+2.20	+1.40		
	30,000	226	5.61	7.46	468.4	16.0	+1.80	+2.40		
	43,000	122	7.83	12.91	938.4	14.2	+6.80	+12.90		
	40,000	141	4.90	7.70	656.2	12.2	+1.10	+5.40		
No Mask Removal	30,000	226**	6.27***	8.36***	697.0***	12.0***	-2.00***	+2.00***		
Mask Removal 73.3 Sec	30,000	226*	----Heart Rate Steady Increase From 86-126-----*							
Recovery	30,000	226*	5.73*	10.77*	624.6*	16.3*	-2.66*	+2.83*		
	1,273	725	8.60	9.602	814.6	12.0	-2.80	+2.10		

* N = 3
** N = 2 Except where otherwise indicated N = 5.
*** N = 1

† No indication of outbaord leakage.
‡ In excess of transducer range.
≠ Heart Rate Steady Decrease From 124-78 in 40 seconds.
φ Heart Rate Steady Decrease Off-Scale to 82 in 30 seconds.
π Heart Rate Steady Decrease From 120-87 in 50 seconds.

Table B3. Mask and Regulator Nitrogen Concentration and Calculated Tracheal-Oxygen Partial Pressure During a Step-Function Altitude-Chamber Flight Profile to 43,000 Feet.

Subject and Condition	Altitude Feet	Barometric Pressure	N_2% Regulator Mean	N_2% Mask Integrated Mean	Mask Pressure ± Barometric Insp.	Exp.	$P_{T_{O_2}} = (B-47)\ F_{I_{O_2}}$ (Mean)	Gas Insp.
C. Pu.	5,000	632	.00	1.90	629.0	632.5	575	O_2 100%
Commercial	18,000	380	.00	2.00	378.0	381.0	326	O_2 100%
Pressure	30,000	226	.00	1.80	224.0	227.0	175	O_2 100%
Schedule 3rd Min. at	43,000	122	.00	1.00	127.0	134.0	83	O_2 100%
	40,000	141	.00	1.30	141.0	141.0	95	O_2 100%
	30,000	226	.00	2.50 (a)	224.0	228.0	175	O_2 100%
	1,273	725	.00	2.00 (b)	723.0	727.0	664	O_2 100%
J. Se.	5,000	632	.25	1.60	629.0	633.5	574	O_2 100%
Commercial	18,000	380	.50	1.50	377.0	381.5	327	O_2 100%
Pressure	30,000	226	.20	.75	224.0	231.0	174	O_2 100%
Schedule	43,000	122	.20	.75	126.0	135.5	83	O_2 100%
	40,000	141	.10	.50	142.0	147.0	97	O_2 100%
	30,000	226	------Rapid Descent - No Readings Were Taken------					O_2 100%
	1,273	725	.20	.75	721.0	727.0	672	O_2 100%
B. Or.	5,000	632	.50	1.40	629.5	634.0	576	O_2 100%
Military	18,000	380	1.50	1.50	378.0	381.5	328	O_2 100%
Pressure	30,000	226	.50	1.50	225.0	229.0	177	O_2 100%
Schedule	43,000	122	.25	.75	133.0	137.0	87	O_2 100%
	40,000	141	.30	.75	143.5	149.0	98	O_2 100%
Just Prior to Mask Removal	30,000	226	.40	.75	224.5	229.0	179	O_2 100%
Mask Removal 82.5 Sec	30,000	226	.25	80.00	Mask Off-----------------			Air
Recovery	30,000	226	4.00	3.00	222.0	229.5	173	O_2 100%
	1,273	725	1.00	1.50	722.0	727.5	667	O_2 100%
C. Pr.	5,000	632	.50	1.50	629.0	633.0	575	O_2 100%
Military	18,000	380	2.00	2.00	378.5	381.0	326	O_2 100%
Pressure	30,000	226	.25	.75	225.0	228.0	178	O_2 100%
Schedule	43,000	122	.25	.75	131.0	137.0	86	O_2 100%
	40,000	141	.25	1.00	143.0	147.0	97	O_2 100%
Mask Removal 92.5 Sec	30,000	226	.00	80.00	Mask Off-----------------			Air
Recovery	30,000	226	3.50	2.50	225.0	228.0	175	O_2 100%
	1,273	725	3.00	1.70	723.0	726.5	666	O_2 100%
J. Si.	1,273	725	.00	-----	722.0	727.5	---	O_2 100%
Commercial	5,000	632	.00	2.40	629.0	634.0	570	O_2 100%
Pressure	18,000	380	.00	3.30	377.5	382.0	322	O_2 100%
Schedule	30,000	226	.00	2.80	224.0	227.0	174	O_2 100%
	43,000	122	.00	.75	127.0	131.0	81	O_2 100%
	40,000	141	.00	.75	141.0	144.0	95	O_2 100%
Mask Removal 45.0 Sec	30,000	226	.00	80.00	Mask Off-----------------			Air
Recovery	30,000	226	.00	5.00	223.0	229.0	170	O_2 100%
	1,273	725	.00	1.60(c)	722.0	727.5	667	O_2 100%
MEAN:	5,000	632	.25	1.76	629.1	633.4	574.0	O_2 100%
	18,000	380	.80	2.06	377.8	381.5	325.8	O_2 100%
	30,000	226	.19	1.52	224.4	228.4	175.6	O_2 100%
	43,000	122	.14	.80	128.8	134.9	84.0	O_2 100%
	40,000	141	.13	.86	142.1	145.6	96.4	O_2 100%
No Mask Removal	30,000	226*	.00**	2.65**	224.0**	227.5**	174.5**	O_2 100%
Mask Removal 73.3 Sec	30,000	226**	.13**	80.00**	-----	-----	-----	Air
Recovery	30,000	226**	3.75**	2.75**	223.5**	228.8**	174.0**	O_2 100%
	1,273	725	.84	1.51	722.2	727.1	667.2	O_2 100%

* N = 3
** N = 2

NOTE: Where not otherwise noted N = 5.

(a) N_2 7% head movement
(b) N_2 12% head movement
(c) N_2 9% head movement

NOTE: Extreme deliberate head movements increased leakage to values indicated.

Table B4. Instantaneous and Mean Heart Rate During a Step-Function Altitude Chamber Flight Profile to 43,000 Feet.

Subject and Condition	Altitude Feet	Barometric Pressure	Heart Rate	Cardiotachometer Min.	Cardiotachometer Max.	Respiratory Rate	Gas Inspired	
C. Pu.	5,000	632	84	78	95	16	O_2 100%	
Commercial	18,000	380	84	80	90	16	O_2 100%	
Pressure	30,000	226	86	80	100	18	O_2 100%	
Schedule	43,000	122	109	90	120	11	O_2 100%	
	40,000	141	85	Excess Movement		11	O_2 100%	
No Mask Removal	30,000	226	82	76	100	12	O_2 100%	
	1,273	725	77	74	95	11	O_2 100%	
J. Se.	5,000	632	82	78	102	11	O_2 100%	
Commercial	18,000	380	87	82	100	13	O_2 100%	
Pressure	30,000	226	89	80	105	13	O_2 100%	
Schedule	43,000	122	104	94	118	19	O_2 100%	
	40,000	141	96	82	108	11	O_2 100%	
No Mask Removal	30,000	226	---	---	---	--	O_2 100%	
	1,273	725	77	70	90	11	O_2 100%	
B. Or.	5,000	632	79	76	96	14	O_2 100%	
Military	18,000	380	90	80	98	19	O_2 100%	
Pressure	30,000	226	84	77	97	17	O_2 100%	
Scale	43,000	122	119	101	126	19	O_2 100%	
	40,000	141	85	82	102	14	O_2 100%	
Just Prior to Mask Removal	30,000	226	80	78	86	12	O_2 100%	
Mask Removal 82.5 Sec	30,000	226	98	82	124+	--	Air	(a)
Recovery	30,000	226	87	78	124+	18	O_2 100%	(b)
	1,273	725	74	64	87	11	O_2 100%	
C. Pr.	5,000	632	102	92	110	21	O_2 100%	
Military	18,000	380	103	97	111	18	O_2 100%	
Pressure	30,000	226	101	98	114	17	O_2 100%	
Scale	43,000	122	140	---Off-Scale--		8	O_2 100%	
	40,000	141	115	80	Off-Scale	9	O_2 100%	
Mask Removal 92.5 Sec	30,000	226	118	82	Off-Scale	--	Air	(c)
Recovery	30,000	226	91	82	112	13	O_2 100%	(d)
	1,273	725	110	90	120	15	O_2 100%	
J. Si.	1,273	725	95	80	112	13	O_2 100%	
Commercial	5,000	632	93	88	112	16	O_2 100%	
Pressure	18,000	380	96	86	108	15	O_2 100%	
Schedule	30,000	226	94	85	98	15	O_2 100%	
	43,000	122	107	92	118	14	O_2 100%	
	40,000	141	98	85	114	16	O_2 100%	
Mask Removal 45.0 Sec	30,000	226	104	96	120	--	Air	(e)
Recovery	30,000	226	100	87	120	18	O_2 100%	(f)
	1,273	725	89	84	104	12	O_2 100%	
MEAN:	5,000	632	88.0	82.40	103.0	15.6		
	18,000	380	92.0	85.00	101.4	16.2		
	30,000	226	90.8	84.00	102.8	16.0		
	43,000	122	115.8	94.25*	120.5*	14.2		
	40,000	141	95.8	82.25*	108.0**	12.2		
No Mask Removal	30,000	226***	82.0***	76.00***	100.0***	12.0***		
Mask Removal 73.3 Sec	30,000	226**	106.6**	86.60**	122.0***	----		
Recovery	30,000	226**	92.6**	82.30**	118.6**	16.3**		
	1,273	725**	85.4**	76.40**	99.2**	12.0**		

* N = 4
** N = 3
*** N = 2

NOTE: Where not otherwise indicated N = 5.

(a) H. R. Steady Increase 82-125
(b) H. R. Steady Decrease 124-78 in 40 Seconds
(c) H. R. Steady Increase 80-Off-Scale
(d) H. R. Steady Decrease Off-Scale-82 in 30 Seconds
(e) H. R. Steady Increase 96-120
(f) H. R. Steady Decrease 120-87 in 50 Seconds

TABLE B5. Summary of Speech Intelligibility, Complex Coordination and Personal Equipment Worn During Chamber Flights to 43,000 Feet.

Subject and equipment	Altitude (feet)	Chamber condition	Subjective speech intelligibility (Volume and clarity)	Complex-coordination task (Time per block)
C. PU.	1,273	Asc.	5 × 5	Pre 43,000 ft.
Polyurethane	18,000	Level	5 × 5	Average baseline
suspension with	18,000	Asc.		2.70
MBU5/P facepiece	30,000	Level	5 × 5	
United Airlines	30,000	Asc.		
6F–2992–1 ear-	43,000	Level	5 × 4	4.24
phones	43,000	Desc.		
Mask microphone	40,000	Desc.	5 × 5	
Commercial	30,000	Level	5 × 5	
regulator	30,000	Desc.		
J. SE.	1,273	Asc.	5 × 5	Pre 43,000 ft
Polyurethane	18,000	Level	5 × 5	Average baseline
suspension with	18,000	Asc.	5 × 5	2.48
MBU5/P facepiece	30,000	Level	5 × 5	
United Airlines	30,000	Asc.		
6F-2992-1 ear	43,000	Level	4 × 5	3.00
phones	43,000	Desc.		
Mask microphone	40,000	Level	5 × 4	
Commercial	40,000	Desc.		
regulator				
B. OR.	5,000	Asc.	5 × 4	Pre 43,000 ft
Aluminum	18,000	Level	5 × 4	Average baseline
suspension with	18,000	Asc.		2.85
Sierra 358–05	30,000	Level	5 × 4	
facepiece	30,000	Asc.		
Minitel MS-50-1	43,000	Level	5 × 4	
Boom microphone	43,000	Desc.		
Military	40,000	Level	5 × 4	
regulator	40,000	Desc.		
	*30,000	Level	5 × 4	3.20
	30,000	Desc.		
C. PR.	1,273	Asc.	5 × 5	Pre 43,000 ft
Aluminum	18,000	Level	5 × 5	Average baseline
suspension with	18,000	Asc.	4 × 4	3.64
Sierra 358–05	30,000	Level		
facepiece	30,000	Asc.		
Minitel MS-50-1	43,000	Level	4 × 4	
Boom microphone	43,000	Desc.		
Military	40,000	Level	5 × 5	
regulator	40,000	Desc.		
	*30,000	Level		5.01
	30,000	Desc.		
J. SI.	5,000	Asc.		
Polyurethane	18,000	Level	5 × 5	
suspension with	30,000	Level	5 × 4	2.30
MBU5 facepiece	30,000	Asc.		
United Airlines	43,000	Level	5 × 4	2.38
6F-2992-1 ear-	40,000	Level	5 × 4	
phones	40,000	Desc.		
Commercial	*30,000	Level		3.47
regulator	30,000	Desc.		

* Mask Removal and Redonning.

Table B6 Ventilation Volume, Pressure, and Frequency During Rapid Decompression From 8,000 to 40,000 Feet. Mask Worn and Regulator in 100% Oxygen Position Prior to and During the Decompression.

Subject and Condition	Altitude Feet	Barometric Pressure mm. Hg.	Min. Vol. L/Min. ATPD	V_I Min. Vol. L/Min. BTPS	V_T Tidal Vol. cc. BTPS	Resp. Rate	Impedance Pneumograph Factor	Mask Pressure mm. Hg. Insp.	Exp.	Insp. Gas
C. Pu.	1,273	737.3	6.44	7.23	628	11.5	.84	-1.5	+1.0	O_2 100%
	8,000	565.0	5.49	6.28	570	11.0	1.00	-2.0	+1.0	O_2 100%
R.D. 50 Sec.	8-40,000	250.0	6.22	8.03	730	11.0	2.40	-2.5	+6.0	O_2 100%
1 Min.	40,000	141.0	6.65	10.47	1,047	10.0	2.00	+4.0	+7.8	O_2 100%
2 Min.	40,000	141.0	3.74	5.88	653	9.0	1.50	+4.0	+6.0	O_2 100%
3 Min.	40,000	141.0	4.21	6.63	828	8.0	1.40	+3.0	+6.0	O_2 100%
C. Pr.	8,000	565.0	6.56	7.51	751	10.0	1.00	-2.0	+1.0	O_2 100%
R.D. 49 Sec.	8-40,000	250.0	3.60	4.65	423	11.0	.73	-2.0	+7.0	O_2 100%
1 Min.	40,000	141.0	13.30	20.95[b]	2,095[b]	10.0	1.30	+3.0	+6.0	O_2 100%
2 Min.	40,000	141.0	12.40	19.55[c]	1,777[c]	11.0	1.50	+3.0	+6.0	O_2 100%
3 Min.	40,000	141.0	10.50	16.53[d]	2,066[d]	8.0	1.10	+3.0	+6.0	O_2 100%
B. Or.	1,273	735.6	6.00	6.74	374	18.0	.90	-2.0	+1.0	O_2 100%
	8,000	565.0	5.20	5.95	372	16.0	1.00	-2.0	+2.0	O_2 100%
R.D. 49 Sec.	8-40,000	250.0	7.52	9.72	512	19.0	4.30	-1.0	+6.0	O_2 100%
1 Min.	40,000	141.0	8.63	13.59	906	15.0	3.75	+4.0	+8.0	O_2 100%
2 Min.	40,000	141.0	7.49	11.79	842	14.0	3.50	+2.5	+6.0	O_2 100%
3 Min.	40,000	141.0	7.49	11.79	842	14.0	3.50	+3.0	+6.0	O_2 100%
J. Se.	1,273	732.4	4.33	4.87	348	14.0	.58	-1.5	+1.0	O_2 100%
	8,000	565.0	3.17	3.63	403	9.0	1.00	-1.0	+1.0	O_2 100%
R.D. 49 Sec.	8-40,000	250.0	2.29*	2.95*	268*	11.0*	3.05	-1.0	+13.0	O_2 100%
1 Min.	40,000	141.0	4.62	7.27	727	10.0	2.77	+4.5	+8.5	O_2 100%
2 Min.	40,000	141.0	3.46	5.46	546	10.0	2.77	+5.0	+8.0	O_2 100%
3 Min.	40,000	141.0	3.46	5.46	546	10.0	2.50	+4.0	+8.0	O_2 100%
J. Si.	1,273	737.0	8.11	9.12	651	14.0	1.20	-2.0	+2.0	O_2 100%
	8,000	565.0	7.36	8.43	602	14.0	1.00	-2.0	+1.0	O_2 100%
R.D. 53 Sec.	8-40,000	250.0	6.22	8.03	618	13.0	3.71	-3.0	+12.0	O_2 100%
1 Min.	40,000	141.0	6.91	10.87	776	14.0	3.50	+4.0	+8.0	O_2 100%
2 Min.	40,000	141.0	4.58	7.22	516	14.0	----	+2.0	+7.0	O_2 100%
3 Min.	40,000	141.0	4.58	7.22	516	14.0	----	+3.0	+6.0	O_2 100%
Post R.D.	1,273	737.0	7.44	8.36	557	15.0	----	-2.0	+1.0	O_2 100%
MEAN:	1,273	735.5	6.22	6.99	500	14.4	.75	-1.7	+1.2	O_2 100%
	8,000	565.0	5.56	6.36	539	12.0	1.00	-1.8	+1.2	O_2 100%
R.D. 50 Sec.	8-40,000	250.0	5.17	6.87	510	13.0	2.84	-1.9	+8.8	O_2 100%
1 Min.	40,000	141.0	9.34	12.63[a]	1,110[a]	11.8	2.71	+3.9	+7.66	O_2 100%
2 Min.	40,000	141.0	7.72	9.98[a]	867[a]	10.1	2.55	+3.3	+6.2	O_2 100%
3 Min.	40,000	141.0	6.05	9.75	968	10.8	2.12	+3.2	+6.4	O_2 100%

(a) Mean corrected for outboard leakage during pressure breathing. Leakage values in BTPS.
(b) Values corrected for outboard leakage of 10.4 L/Min.
(c) Values corrected for outboard leakage of 10.9 L/Min.
(d) Outboard leakage terminated.
* Values omitted in calculation of mean.

Table B7. Mask and Regulator Nitrogen Concentration, Calculated Tracheal-Oxygen Partial Pressure, and Indicated Blood-Oxygen Saturation. Mask Worn Prior to and During the Decompression

Subject and Condition	Altitude Feet	Barometric Pressure	N_2% Regulator Peak	N_2% Regulator Min.	N_2% Mask Peak	N_2% Mask Min.	Mask Pressure ± Barometric P. Insp.	Mask Pressure ± Barometric P. Exp.	$P_{T_{O_2}}$ (B-47) $P_{F_{I_{O_2}}}$ (Mean)	Ear Oximeter % Sat.	Gas Insp.
C. Pu.	1,273	737.3	--	--	--	--	--	--	--	96.0	Air
	1,273	737.3	2.00	2.00	3.00	1.50	735.8	738.3	684.0	98.0	O_2 100%
	8,000	565.0	3.00	1.80	3.00	2.00	563.0	566.0	505.0	96.0	O_2 100%
R.D. 50 Sec.	8-40,000	250.0	--	--	--	--	247.5	256.0	--	94.7	O_2 100%
1 Min.	40,000	141.0	1.80	.50	1.50	.20	145.0	148.0	99.0	93.0	O_2 100%
2 Min.	40,000	141.0	1.00	.20	.75	.20	145.0	147.0	98.5	93.0	O_2 100%
3 Min.	40,000	141.0	.75	.20	1.00	.20	144.0	147.0	98.0	94.0	O_2 100%
	1,273	737.3	--	--	--	--	--	--	--	93.0	Air
C. Pr.	1,273	734.6	--	--	--	--	--	--	--	95.0	Air
	1,273	734.6	3.00	1.75	3.50	2.00	--	--	--	97.0	O_2 100%
	8,000	565.0	3.00	1.50	3.00	1.50	563.0	566.0	506.0	96.0	O_2 100%
R.D. 49 Sec.	8-40,000	250.0	1.20	.50	3.50	2.00	248.0	257.0	200.0	95.0	O_2 100%
1 Min.	40,000	141.0	.20	.20	.75	0.00	144.0	147.0	98.0	93.5	O_2 100%
2 Min.	40,000	141.0	.50	.50	.50	0.00	144.0	147.0	98.0	93.5	O_2 100%
3 Min.	40,000	141.0	1.00	.50	.50	0.00	144.0	147.0	98.0	93.5	O_2 100%
Mask Removed	6,000	609.0	--	--	--	--	--	--	--	97.0	Air
B. Or.	1,273	735.6	--	--	--	--	--	--	--	96.0	Air
	1,273	735.6	2.50	1.20	3.00	1.50	733.6	736.6	673.0	97.0	O_2 100%
	8,000	565.0	3.00	1.50	3.00	2.00	564.0	567.0	505.0	96.5	O_2 100%
R.D. 49 Sec.	8-40,000	141.0	.75	.75	1.00	4.00	249.0	256.0	200.0	95.0	O_2 100%
1 Min.	40,000	141.0	1.75	.75	.75	.25	145.0	149.0	99.5	94.5	O_2 100%
2 Min.	40,000	141.0	.80	.30	.50	0.00	143.5	147.0	98.0	95.0	O_2 100%
3 Min.	40,000	141.0	.75	.25	.50	0.00	144.0	147.0	98.0	95.0	O_2 100%
	1,273	141.0	--	--	--	--	--	--	--	93.0	Air
J. Se.	1,273	730.9	--	--	--	--	--	--	--	93.5	Air
	1,273	730.9	.20	.20	.75	.20	730.9	733.4	682.0	97.5	O_2 100%
	8,000	565.0	.20	.20	.75	.50	564.0	566.0	515.0	97.5	O_2 100%
R.D. 49 Sec.	8-40,000	250.0	.50	.50	1.20	.50	254.0	258.0	207.0	97.2	O_2 100%
1 Min.	40,000	141.0	.20	.20	.40	0.00	145.5	149.5	100.0	96.0	O_2 100%
2 Min.	40,000	141.0	.30	.30	.40	0.00	146.0	149.0	100.0	95.1	O_2 100%
3 Min.	40,000	141.0	.30	.30	.40	0.00	145.0	149.0	100.0	95.0	O_2 100%
	32,000	206.5	--	--	--	--	--	--	--	95.9	O_2 100%
	25,000	282.4	--	--	--	--	--	--	--	96.4	O_2 100%
	14,000	447.0	--	--	--	--	--	--	--	97.1	O_2 100%
J. Si.	1,273	737.0	.75	.75	2.00	1.00	735.0	739.0	680.0	97.0	O_2 100%
	8,000	565.0	.75	.75	2.00	1.00	563.0	566.0	510.0	97.0	O_2 100%
R.D. 53 Sec.	8-40,000	250.0	1.00	1.00	1.50	.75	251.0	254.0	205.0	96.0	O_2 100%
1 Min.	40,000	141.0	.75	.75	1.00	.50	145.0	149.0	99.0	95.0	O_2 100%
2 Min.	40,000	141.0	.50	.50	1.00	.75	143.0	148.0	98.0	95.0	O_2 100%
3 Min.	40,000	141.0	.50	.50	1.00	.50	144.0	147.0	98.0	94.0	O_2 100%
	1,273	737.0	.80	.80	2.00	1.00	735.0	738.0	679.0	99.0	O_2 100%
MEAN:	1,273	735.1	1.69	1.18	2.45	1.24	733.8	736.8	679.8	97.30	
	8,000	565.0	1.99	1.15	2.35	1.40	563.4	566.2	508.2	96.60	
R.D. 50 Sec.	8-40,000	228.2	.86*	.69*	1.80*	1.81	250.0	256.2	203.0*	95.58	
1 Min.	40,000	141.0	.94	.48	.88	.19	144.9	148.5	99.1	94.40	
2 Min.	40,000	141.0	.62	.36	.63	.19	144.3	147.6	98.5	94.32	
3 Min.	40,000	141.0	.66	.35	.68	.14	144.2	147.4	98.4	94.30	

* N = 4

NOTE: Exceptfor where otherwise indicated N = 5.

TABLE B8. Instantaneous and Mean Heart Rates, Respiratory Rate, and Indicated Blood-Oxygen Saturation. Mask Worn Prior to and Decompression.

Subject and Condition	Altitude Feet	Barometer Pressure	Heart Rate	Cardiotachometer Min.	Max.	Oximeter % Sat.	Respiration Rate	Gas Inspired
C. Pu.	1,273	737.3	72	67	86	98	11.5	O_2 100%
	8,000	565.0	74	--	--	96	11.0	O_2 100%
R.D. 50 Sec.	8-40,000	250.0	72	--	--	94.7	11.0	O_2 100%
1 Min.	40,000	141.0	76	--	--	93.0	10.0	O_2 100%
2 Min.	40,000	141.0	82	--	--	93.0	9.0	O_2 100%
3 Min.	40,000	141.0	78	--	--	94.0	8.0	O_2 100%
C. Pr.	1,273	734.6	--	--	--	97.0	--	O_2 100%
	8,000	565.0	91	75	113	96.0	10.0	O_2 100%
R.D. 49 Sec.	8-40,000	250.0	89	65	109	95.0	11.0	O_2 100%
1 Min.	40,000	141.0	--	--	--	93.5	10.0	O_2 100%
2 Min.	40,000	141.0	--	--	--	93.5	11.0	O_2 100%
3 Min.	40,000	141.0	98	80	112	93.5	8.0	O_2 100%
B. Or.	1,273	735.6	75	68	87	97.0	18.0	O_2 100%
	8,000	565.0	78	72	96	96.5	16.0	O_2 100%
R.D. 49 Sec.	8-40,000	250.0	84	74	97	95.0	19.0	O_2 100%
1 Min.	40,000	141.0	--	--	--	94.5	15.0	O_2 100%
2 Min.	40,000	141.0	--	--	--	95.0	14.0	O_2 100%
3 Min.	40,000	141.0	--	--	--	95.0	14.0	O_2 100%
J. Se.	1,273	732.4	76	70	87	97.5	14.0	O_2 100%
	8,000	565.0	73	65	87	97.5	9.0	O_2 100%
R.D. 49 Sec.	8-40,000	250.0	82	72	100	97.2	11.0	O_2 100%
1 Min.	40,000	141.0	94	82	102	96.0	10.0	O_2 100%
2 Min.	40,000	141.0	95	85	100	95.1	10.0	O_2 100%
3 Min.	40,000	141.0	92	84	105	95.0	10.0	O_2 100%
J. Si.	1,273	737.0	--	--	--	97.0	14.0	O_2 100%
	8,000	565.0	82	70	98	97.0	14.0	O_2 100%
R.D. 53 Sec.	8-40,000	250.0	87	77	105	96.0	13.0	O_2 100%
1 Min.	40,000	141.0	94	84	104	95.0	14.0	O_2 100%
2 Min.	40,000	141.0	91	85	105	95.0	14.0	O_2 100%
3 Min.	40,000	141.0	--	--	--	94.0	14.0	O_2 100%
MEAN:	1,273	735.4	74.3**	68.3**	86.6**	97.3	14.4*	
	8,000	565.0	79.6	70.5*	100.0*	96.6	12.0	
R.D. 50 Sec.	8-40,000	250.0	82.8	72.0*	102.8*	95.6	13.0	
1 Min.	40,000	141.0	88.0**	83.0***	103.0***	94.4	12.0	
2 Min.	40,000	141.0	89.3**	85.0***	102.5***	94.3	11.6	
3 Min.	40,000	141.0	89.3**	82.0***	108.5***	94.3	10.8	

* N = 4
** N = 3
*** N = 2

NOTE: Where not otherwise indicated N 5.

TABLE B9. Respiratory Nitrogen Washout, Mask-Donning Time, and Decompression Profile of Subjects Utilizing the Hanging-Type Puritan Sweep-on Mask, Equipped With the Semi-Rigid Face Piece During a Chamber Study Conducted June 1963. Rapid Decompression from 6,000 to 41,000 Feet.

HEART RATE			NITROGEN WASHOUT		DECOMPRESSION PROFILE				
Condition	Altitude	Heart Rate	Following Mask Donning During Decompression Time	% Nitrogen	Altitudes Feet	Time Seconds	Donning Signal Altitude Feet	Donning Time in Seconds	Donning Altitude in Feet
SUBJECT F. N.									
Ground Level	1,273	---	0 Sec.	80.0%	6,000-14,000	5.8			
Pre R.D.	6,000	60	15 Sec.	47.0%	14,000-25,000	8.5			
Start R.D.	6--41,000	111	30 Sec.	19.5%	25,000-29,000	5.8	25,000	5.8	29,000
End R.D.	41,000	90	45 Sec.	11.0%	Total Decompression Time 6-41,000 = 47.5 Sec.				
Resting At G. L.	1,273	84	1 Min.	8.0%					
			2 Min.	3.0%					
			3 Min.	2.0%					
SUBJECT K. S.									
Ground Level	1,273	60	0 Sec.	Air 80.0%	6,000-14,000	4.5			
Pre R.D.	6,000	75	15 Sec.	46.0%	14,000-25,000	10.0			
Start R.D.	6,000-41,000	99	30 Sec.	40.0%	25,000-32,000	8.2	25,000	8.2	32,000
End R.D.	41,000	66	45 Sec.	24.0%	Total Decompression Time 6-41,000 = 45.0 Sec.				
Resting At G. L.	1,273	60	1 Min.	19.0%					
			2 Min.	7.8%					
			3 Min.	3.0%					
SUBJECT B. T.									
Ground Level	1,273	---	0 Sec.	Air 80.0%	6,000-14,000	5.5			
Pre R.D.	6,000	72	15 Sec.	34.0%	14,000-25,000	8.0			
Start R.D.	6,000-41,000	102	30 Sec.	15.0%	25,000-29,000	4.7	25,000	4.7	29,000
End R.D.	41,000	102	45 Sec.	6.0%	Total Decompression Time 6-41,000 = 41.0 Sec.				
Resgint At G. L.	1,273	72	1 Min.	5.0%					
			2 Min.	1.0%					
			3 Min.	0.0%					
SUBJECT J. Y.									
Ground Level	1,273	78	0 Sec.	Air 80.0%	6,000-14,000	5.0			
Pre R.D.	6,000	78	15 Sec.	23.0%	14,000-25,000	8.5			
Start R.D.	6,000-41,000	84	30 Sec.	9.0%	25,000-32,000	5.9	25,000	5.9	30,000
End R.D.	41,000	90	45 Sec.	5.0%	Total Decompression Time 6-41,000 = 49.0 Sec.				
			1 Min.	2.0%					
			2 Min.	2.0%					
			3 Min.	1.5%					
SUBJECT G. P.									
Ground Level	1,273	---	0 Sec.	Air 80.0%	6,000-14,000	4.5			
Pre R.D.	6,000	69	15 Sec.	70.0%	14,000-25,000	9.0			
Start R.D.	6,000-41,000	81	30 Sec.	13.0%	25,000-33,000	6.2	25,000	6.2	33,000
End R.D.	41,000	87	45 Sec.	2.0%	Total Decompression Time 6-41,000 = 42.5 Sec.				
			1 Min.	2.0%					
			2 Min.	0.0%					
			3 Min.	0.0%					
SUBJECT J.D.A.									
Ground Level	1,273	91	0 Sec.	80.0%	6,000-14,000	5.0			
Pre. R.D.	6,000	117	15 Sec.	20.0%	14,000-25,000	9.5			
Start R.D.	6,000-41,000	147	30 Sec.	5.0%	25,000-30,000	4.8	25,000	4.8	30,000
End R.D.	41,000	162	45 Sec.	2.0%	Total Decompression Time 6-41,000 = 42.0 Sec.				
Resting G. L.	1,273	108	1 Min.	2.0%	This subject developed acute hyperventilation syndrome. Was not responsive to oral, visual or tactile communication until 16,500 feet, attained during emergency descent.				
			2 Min.	0.0%					
			3 Min.	0.0%					
MEANS									
Ground Level	1,273	76.3**	0 Sec.	80.0%	6,000-14,000	5.05			
Pre R.D.	6,000	78.5	15 Sec.	40.0%	14,000-25,000	8.92			
Start R.D.	6,000-41,000	104.0	30 Sec.	16.9%	25,000-29,000	5.93	25,000	5.93	30,500
End R.D.	41,000	82.8	45 Sec.	8.3%	Total Decompression Time 6-41,000 = 44.5 Sec.				
Resting At G.L.	1,273	81.0*	1 Min.	6.3%					
			2 Min.	2.3%					
			3 Min.	1.1%					

* N = 4
** N = 3

Except where otherwise indicated N = 6.

TABLE B10. Ventilation Volume, Presure, and Frequency During Rapid Decompression from 8,000 to 40,000 Feet. Mask Donning Accomplished During the Decompression.

Subject and Condition		Altitude Feet	Barometric Pressure	Min. Vol. L/Min. ATPD	Min. Vol. L/Min. BTPS	Tidal Vol. cc. BTPS	Resp. Rate	Impedance Pneumograph Factor	Mask Pressure mm. Hg. Insp	Exp.	Insp. Gas
C. Pu.		1,273	730.5	4.00	4.45	318	14	1.00	-1.00	+1.50	O_2 100%
		8,000	565.0	4.34	4.97	355	14	1.00	-1.00	+1.50	O_2 100%
											Air 2 Min Pre R.D.
R.D.	51 Sec.	8-40,000	183.0	3.77	5.31	442	12	3.86	-1.00	+8.00	O_2 100%
Don Mask	1 Min.	40,000	141.0	9.20	14.49	1,317	11	2.36	+4.00	+9.00	O_2 100%
30 Seconds	2 Min.	40,000	141.0	5.77	9.09	826	11	2.36	+4.00	+8.00	O_2 100%
28,000 Feet	3 Min.	40,000	141.0	5.77	9.09	1,010	9	1.60	+5.00	+8.50	O_2 100%
C. Pr.		1,273	721.6	5.50	6.17	561	11	----	-1.00	+1.50	O_2 100%
		8,000	565.0	5.20	5.95	330	18	1.00	-1.00	+1.00	O_2 100%
		8,000	565.0	----	----	---	18	1.00	----	----	Air 2 Min Pre R.D.
R.D.	49 Sec.	8-40,000	178.0	11.22	16.02	1,001	16	24.00	±0.00	+10.00	O_2 100%
Don Mask	1 Min.	40,000	141.0	8.94	14.08	1,564	9	10.50	+4.00	+10.50	O_2 100%
34 Seconds	2 Min.	40,000	141.0	7.23	11.38	1,138	10	11.80	+4.00	+8.00	O_2 100%
31,000 Feet	3 Min.	40,000	141.0	6.92	10.90	1,211	9	10.20	+5.00	+8.50	O_2 100%
B. Or.		1,273	732.3	7.17	8.06	537	15	1.00	-2.00	-1.50	O_2 100%
		8,000	565.0	5.85	6.69	446	15	1.00	-1.50	+1.50	O_2 100%
											Air 2 Min Pre R.D.
R.D.	49 Sec.	8-42,000	182.0	10.63	15.06	1,004	15	7.00	-1.50	+8.00	O_2 100%
Don Mask	1 Min.	42,000	128.0	10.97	18.20	1,137	16	3.20	+8.00	+13.00	O_2 100%
29 Seconds	2 Min.	42,000	128.0	8.06	13.36	954	14	2.80	+6.00	+11.50	O_2 100%
29,000 Feet	3 Min.	42,000	128.0	6.34	10.52	809	13	2.60	+6.00	+11.00	O_2 100%
J. Se.		1,273	735.6	4.28	4.80	369	13	.81	-1.50	+1.50	O_2 100%
		8,000	565.0	4.04	4.62	353	12	1.00	-1.00	+1.50	O_2 100%
		8,000	565.0	----	----	---	15	.62	----	----	Air 2 Min Pre R.D.
R.D.	50 Sec.	8-40,000	182.0	9.26	13.12	1,093	12	4.50	+1.00	+8.00	O_2 100%
Don Mask	1 Min.	40,000	141.0	8.63	13.59	1,132	12	3.00	+4.00	+8.50	O_2 100%
31 Seconds	2 Min.	40,000	141.0	4.58	7.21	601	12	1.50	+5.00	+8.00	O_2 100%
29,000 Feet	3 Min.	40,000	141.0	4.58	7.21	555	13	1.63	+4.00	+8.00	O_2 100%
E. Mc.		1,273	732.4	11.77	13.09	873	15	2.90	-2.00	+2.00	Air ‡
		8,000	565.0	-----	-----	---	18	1.00	----	----	Air
R.D.	49 Sec.	8-40,000	175.0	17.72	25.05	1,392	18	6.00	-2.00	+8.00	O_2 100%
Don Mask	1 Min.	40,000	141.0	16.17	25.20	1,326	19	5.27	+4.00	+11.00	O_2 100%
30 Seconds	2 Min.	40,000	141.0	12.11	18.88	899	21	2.91	+3.00	+10.00	O_2 100%
29,000 Feet.	3 Min.	40,000	141.0	12.11	18.88	994	19	1.68	+5.00	+10.00	O_2 100%
MEAN:		1,273	730.5	6.54	7.31	532	13.6	1.43	-1.50	+1.60	
		8,000	565.0	4.86	5.56	371	15.4	1.00	-1.13	+1.37	
R.D.	49.6 Seconds	8-40,400	180.0	1.05	14.91	986	14.6	9.07	- .70	+8.40	
Don Mask	1.0 Min.	40,400	138.4	10.78	17.11	1,295	13.4	4.87	+4.80	+10.40	
30.8 Seconds	2.0 Min.	40,400	138.4	7.55	11.98	884	13.6	4.27	+4.40	+9.10	
29,200 Feet	3.0 Min.	40,400	138.4	7.14	11.32	916	12.6	3.54	+5.00	+9.20	

NOTE: Mean includes Subject E. Mc who was not de-nitrogenated, and Subject B. Or. whose terminal altitude was 42,000 feet.

‡ Regulator positioned for air only. Subject hyperventilating for calibration of impedance pneumograph.

TABLE B11. Mask and Regulator Nitrogen Concentration, Calculated Tracheal-Oxygen Partial Pressure, and Indicated Blood-Oxygen Saturation. Mask Donning Accomplished During the Decompression.

Subject and Condition	Altitude Feet	Barometric Pressure	N_2% Regulator Peak	N_2% Regulator Min.	N_2% Mask Peak	N_2% Mask Min.	Mask Pressure ± Barometric P. Insp.	Mask Pressure ± Barometric P. Exp.	$P_{T_{O_2}} = (B-47) F_{I_{O_2}}$ (Mean)	Ear Oximeter % Sat.	Gas Insp.
C. Pu.	1,273	730.5	0	0	1.00	.75	729.5	732.0	677.5	97.0	O_2 100%
	8,000	565.0	0	0	.80	.50	564.0	566.5	514.5	97.0	O_2 100%
2 Min. On Air	8,000	565.0	-	-	----	---	-----	-----	-----	97.0	Air
R.D. 51 Sec.	8-40,000	183.5	0	0	45.00	.00	187.5	191.5	79.0	89.0	O_2 100%
Mask Don 1 Min.	40,000	141.0	0	0	1.50	.00	145.0	150.0	100.0	95.5	O_2 100%
30 Seconds 2 Min.	40,000	141.0	0	0	.50	.00	145.0	149.0	100.0	95.9	O_2 100%
28,000 Feet 3 Min.	40,000	141.0	0	0	.00	.00	146.0	149.5	101.0	95.9	O_2 100%
C. Pr.	1,273	721.6	0	0	1.00	.50	720.6	723.1	669.0	96.0	O_2 100%
	8,000	565.0	0	0	1.00	.50	564.0	566.0	514.0	98.0	O_2 100%
2 Min. On Air	8,000	565.0	-	-	-----	----	-----	-----	-----	97.5	Air
R.D. 49 Sec.	8-40,000	178.0	0	0	60.00	2.00	181.0	188.0	56.0	85.0	O_2 100%
Mask Don 1 Min.	40,000	141.0	0	0	2.00	.00	145.0	151.5	100.0	93.0	O_2 100%
34 Seconds 2 Min.	40,000	141.0	0	0	1.00	.00	145.0	149.0	99.5	93.0	O_2 100%
31,000 Feet 3 Min.	40,000	141.0	0	0	.80	.00	146.0	149.5	100.0	94.0	O_2 100%
B. Or.	1,273	732.3	-	-	-----	----	-----	-----	-----	95.0	Air
	1,273	732.3	0	0	.75	.30	730.3	733.8	681.0	95.5	O_2 100%
2 Min. On Air	8,000	565.0	0	0	.60	.25	563.5	566.5	515.0	99.5	O_2 100%
R.D. 49 Sec.	8-42,000	182.0	0	0	23.00	1.00	180.0	190.0	110.0	93.0	O_2 100%
Mask Don 1 Min.	42,000	128.0	0	0	2.00	.00	136.0	141.0	90.5	97.0	O_2 100%
29 Seconds 2 Min.	42,000	128.0	0	0	.80	.00	134.0	139.5	89.3	99.0	O_2 100%
29,000 Feet 3 Min.	42,000	128.0	0	0	.75	.00	134.0	139.5	89.1	99.0	O_2 100%
J. Se.	1,273	735.6	0	0	.80	.50	734.1	737.1	684.0	97.2	O_2 100%
	8,000	565.0	0	0	.75	.50	564.0	566.5	516.0	98.0	O_2 100%
2 Min. On Air	8,000	565.0	-	-	-----	----	-----	-----	-----	97.5	Air
R.D. 50 Sec.	8-40,000	182.0	0	0	16.00	2.00	183.0	190.0	120.0	85.2	O_2 100%
Mask Don 1 Min.	40,000	141.0	0	0	1.00	.50	145.0	149.5	99.0	94.4	O_2 100%
31 Seconds 2 Min.	40,000	141.0	0	0	.75	.30	146.0	149.0	100.0	95.0	O_2 100%
29,000 Feet 3 Min.	40,000	141.0	0	0	.75	.20	145.0	149.0	100.0	95.0	O_2 100%
	30,000	226.0	-	-	-----	----	-----	-----	-----	96.0	O_2 100%
	1,273	735.6	-	-	-----	----	-----	-----	-----	95.0	O_2 100%
E. Mc.	1,273	732.4	-	-	-----	----	-----	-----	-----	96.0	Air
No De-Nitrogenation	8,000	565.0	Air	Air	Air	Air	-----	-----	-----	95.7	Air
R.D. 49 Sec.	8-40,000	175.0	0	0	54.00	.50	173.0	183.0	63.0	84.0	O_2 100%
Mask Don 1 Min.	40,000	141.0	0	0	1.60	.50	145.0	152.0	100.0	99.0	O_2 100%
30 Seconds 2 Min.	40,000	141.0	0	0	1.25	.50	144.0	151.0	100.0	99.0	O_2 100%
29,000 Feet 3 Min.	40,000	141.0	0	0	1.00	.50	146.0	150.0	101.0	99.0	O_2 100%
MEAN:	1,273	730.48	0*	0*	.89*	.51*	728.6*	731.5*	677.9*	96.3	
	8,000	565.00*	0*	0*	.79*	.44*	563.9*	566.4*	514.9*	97.6	
2 Min. On Air	8,000	565.00**	-	-	-----	----	-----	-----	-----	97.3**	
R.D. 49.6 Sec.	8-40,400	180.10	0	0	39.60	1.10	180.9	188.5	85.6	87.2	
Mask Don 1 Min.	40,400	138.40	0	0	1.62	.20	143.2	148.8	98.0	95.8	
30.8 Seconds 2 Min.	40,400	138.40	0	0	.86	.16	142.8	147.5	97.8	96.4	
29,200 Feet 3 Min.	40,400	138.40	0	0	.66	.14	143.4	147.4	98.2	96.6	

* N = 4
** N = 3 NOTE: Where not otherwise noted N = 5.

NOTE: Mean includes Subject E. Mc who was not de-nitrogenated, and Subject B. Or. whose terminal altitude was 42,000 feet.

TABLE B12. Instantaneous and Mean Heart Rates, Respiration, and Indicated Blood-Oxygen Saturation. Mask Donning Accomplished During Decompression.

Subject and Condition	Altitude (Ft)	Barometric Pressure	Heart Rate	Cardiotachometer Min.	Cardiotachometer Max.	Oximeter %Sat.	Respiratory Rate	Gas Inspired
C. Pu.	1,273	730.5	76	76	84	97.0	14	O_2 100%
	8,000	565.0	72	67	80	97.0	14	O_2 100%
2 Min. On Air	8,000	565.0	--	--	--	97.0	14	Air
R.D. 51 Sec.	8-40,000	183.5	84	70	100	89.C	12	O_2 100%
Don Mask 1 Min.	40,000	141.0	90	85	98	95.5	11	O_2 100%
30 Sec. 2 Min.	40,000	141.0	90	84	98	95.9	11	O_2 100%
28,000 Ft. 3 Min.	40,000	141.0	90	84	96	95.9	9	O_2 100%
C. Pr.	1,273	721.6	75	65	90	96.0	11	O_2 100%
	8,000	565.0	86	75	100	98.0	18	O_2 100%
2 Min. On Air	8,000	565.0	92	83	98	97.5	18	Air
R.D. 49 Sec.	8-40,000	178.0	128	--	--	85.0	16	O_2 100%
Don Mask 1 Min.	40,000	141.0	121	--	--	93.0	9	O_2 100%
34 Sec. 2 Min.	40,000	141.0	117	--	--	93.0	10	O_2 100%
31,000 Ft. 3 Min.	40,000	141 0	117	--	--	94.0	9	O_2 100%
B. Or.	1,273	732.3	63	57	68	95.5	15	O_2 100%
	8,000	565.0	63	60	70	99.5	15	O_2 100%
2 Min. On Air	8,000	565.0	--	--	--	--	--	Air
R.D. 49 Sec.	8-42,000	182.0	95	70	125	89.0	15	O_2 100%
Don Mask 1 Min.	42,000	128.0	99	92	110	97.0	16	O_2 100%
29 Sec. 2 Min.	42,000	128.0	91	90	105	99.0	14	O_2 100%
29,000 3 Min.	42,000	128.0	96	87	104	99.0	13	O_2 100%
J. Se.	1,273	735.6	81	74	95	97.2	13	O_2 100%
	8,000	565.0	74	67	83	98.0	12	O_2 100%
2 Min. On Air	8,000	565.0	75	70	89	97.5	15	Air
R.D. 50 Sec.	8-40,000	182.0	107	86	125	85.2	12	O_2 100%
Don Mask 1 Min.	40,000	141.0	98	87	110	94.4	12	O_2 100%
31 Sec. 2 Min.	40,000	141.0	--	--	--	95.0	12	O_2 100%
29,000 Ft. 3 Min.	40,000	141.0	--	--	--	95.0	13	O_2 100%
E. Mc.	1,273	732.4	81	70	93	96.0	15	Air
No De-Nitrogenation	8,000	732.4	96	88	115	95.7	18	Air
R.D. 49 Sec.	8-40,000	175.0	135	80	140	84.0	18	O_2 100%
Don Mask 1 Min.	40,000	141.0	140	135	145	99.0	19	O_2 100%
30 Sec. 2 Min.	40,000	141.0	130	112	135	99.0	21	O_2 100%
29,000 Ft. 3 Min.	40,000	141.0	112	85	125	99.0	19	O_2 100%
MEAN:	1,273	730.5	75.2	66.6	86.0	96.0	13.6	
	8,000	565.0*	73.8*	67.3*	83.3*	98.1*	14.8*	
2 Min. On Air	8,000	565.0*	83.5**	76.5***	93.5***	97.3**	16.0**	
R.D. 49.6 Sec.	8-40,400	180.1	109.8	76.5*	122.5*	86.4	14.6	
Don Mask 1 Min.	40,400	138.4	109.6	99.8*	115.8*	95.8	13.4	
30.8 Seconds 2 Min.	40,400	138.4	107.0*	95.3**	112.7**	96.4	13.2	
29,200 Feet 3 Min.	40,400	138.4	103.8*	85.3**	108.3**	96.6	12.6	

* N = 4
** N = 3
*** N = 2

NOTE: Unless otherwise noted N = 5.