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PERFORMANCE CHARACTERISTICS OF CONSTANT-FLOW PHASE DILUTION OXYGEN MASK DESIGNS FOR GENERAL AVIATION

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I. Introduction.

Recent technological advances in general aviation have resulted in the development of aircraft with increased altitude capability and service ceilings. On January 11, 1966, a stock model single-engine Cessna Turbo-System Centurion set a new world altitude record of 39,334 feet for light aircraft.

Oxygen in aviation was first used by French aeronauts and scientists in the famous flight of the Zenith, a balloon ascension which on April 15, 1875, attained an altitude in excess of 8600 meters (28,000 feet)[1]. Oxygen was breathed from goatskin bags through a scented wash bottle and a small rubber tube held in the mouth. Unfortunately, in attempting to conserve their supply of oxygen, these high altitude pioneers became severely hypoxic and lost consciousness. Of the three members aboard the Zenith flight, only one survived. Up until the development of the constant flow BLB mask just prior to World War II, the mouth-held tube or pipestem was still the most common method of administering oxygen in aviation. Not until late in World War II and thereafter were the demand and pressure demand oxygen systems developed.

Constant-flow rebreather type oxygen masks similar in concept to the BLB are most frequently used in general aviation, due to their relatively low cost and oxygen economy afforded at lower altitudes. One basic disadvantage of constant flow oxygen masks is their inherent inability automatically to adjust to the requirements of the user as influenced by his emotional or physical activity.

Dilution of oxygen in constant flow masks is generally afforded by orifices or dilution ports of a predetermined size which allow a varying amount of air to enter the mask, depending upon the oxygen flowing to the mask and the respiratory activity of the individual wearing the mask. Portions of the exhaled gas, higher in oxygen concentration than air, are returned to the rebreather reservoir bag for re-use. Other portions are vented out through the dilution ports, maintaining carbon dioxide at an acceptable level. At higher altitudes, it becomes increasingly difficult to control and assure high concentrations of oxygen with these types of constant flow or economizer masks unless the mask is flooded with oxygen at uneconomical flow rates. With the advent in 1955 of requirements for short duration emergency protection of commercial jet passengers to altitudes of 40,000 feet following the loss of cabin pressurization, the continuous flow phase dilution mask was developed.[2,3,4] This oxygen mask, which conforms to the National Aerospace Standard NAS 1179, does not employ rebreathing and is so designed that 100% oxygen is delivered to the lungs at the beginning of inspiration.[5] This is most advantageous since toward the end of inspiration air is admitted by a valve only after the oxygen in the reservoir is depleted. Air introduced by the valve may penetrate the mask and physiological dead space only. This portion of the tidal volume is the first to be expelled upon initiation of exhalation. Air under these circumstances never reaches the alveoli of the lungs and is therefore physiologically ineffective.

The continuous flow oxygen masks described in this report and designed primarily for general aviation are outgrowths of these developments and incorporate features of rebreathing and phase dilution masks.

II. Methods.

Two prototypes of new experimental rebreathing—phase dilution masks manufactured by the Scott Aviation Corporation were evaluated at altitude on resting and active subjects. These tests were designed to evaluate the physiological adequacy and efficiency of the mask as well as the oxygen system as an entity. For comparative purposes, one test was conducted using a currently manufactured Scott Sky Mask incorporating rebreathing and open dilution ports (Figure 1).

One of the prototype rebreathing masks was similar in design to the Scott Sky Mask, but instead of open dilution ports incorporated a foam porous restrictive dilution port (Figure 2). The other prototype incorporated a mask-mounted microphone and a non-porous flapper type valve in lieu of the open dilution ports (Figure 3). A Scott automatic constant flow regulator Model Number 25620-3 and eight outlets were installed in the altitude chamber similar to an aircraft installation. Electrocardiograph and impedance pneumograph electrodes were affixed to the subjects in order to obtain heart and respiratory rates. Mask and end expiratory nitrogen were monitored continuously by two nitralyzers connected to the mask through microcatheter tubing (PE 60) of .03 inches internal diameter. One of the nitralyzers was connected to an integrating reservoir mounted on the mask. The other nitralyzer continuously

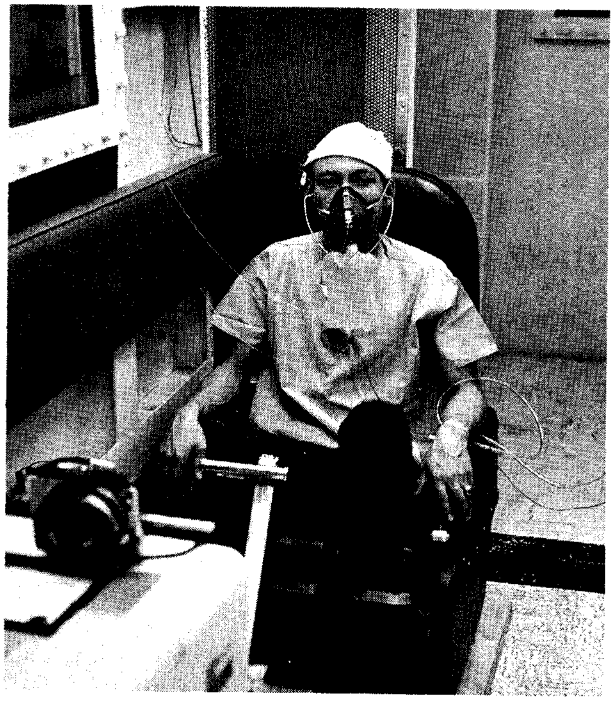

FIGURE 2.—Subject wearing a Scott prototype mask incorporating a foam porous restrictive dilution port.

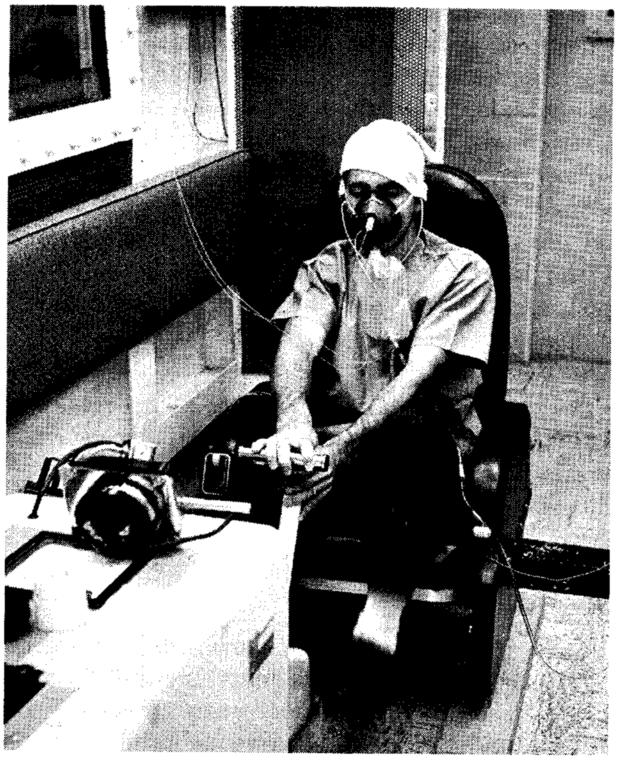

FIGURE 1.—Subject wearing the open dilution port Scott Sky Mask engaged in light exercise on the bicycle ergometer at altitude.

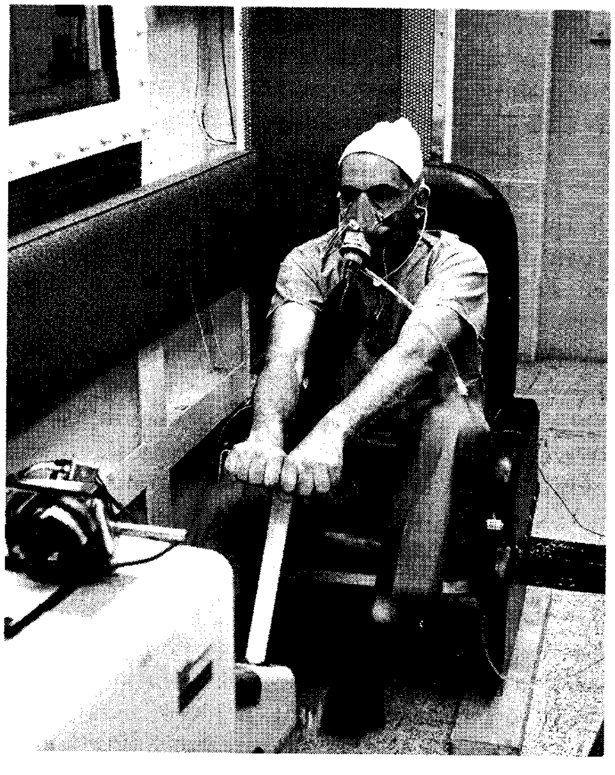

FIGURE 3.—Subject wearing a Scott prototype mask incorporating a nonporous flapper type valve. Mask is also equipped with maskmounted microphone.

analyzed composition of end expiratory gas withdrawn from a sampler inserted into one nostril (Figure 4).

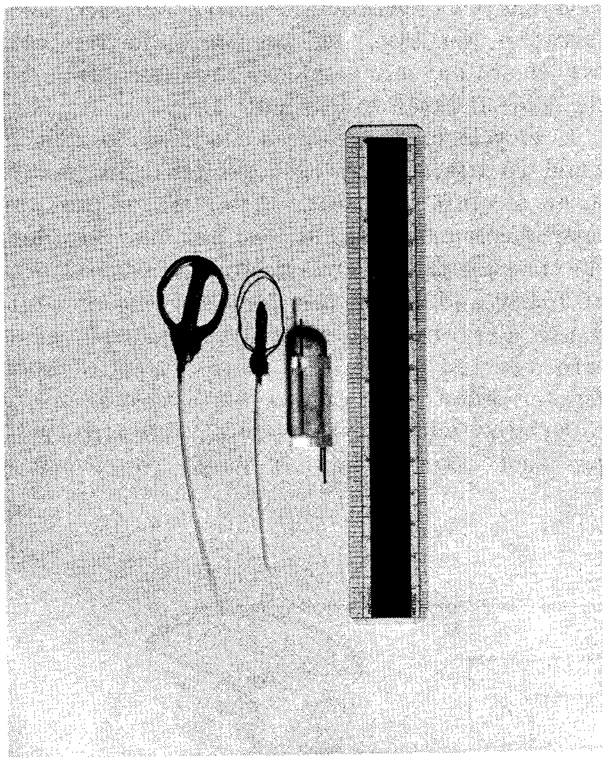

FIGURE 4.—Two sizes of end expiratory nasal samplers and integrating reservoir.

In the evaluation of oxygen mask efficiency, one of the most important factors is the partial pressure of gases in the inspired gas. A rebreathing mask defies direct measurement of these parameters, due to the rapidly varying non-homogeneous gas mixtures introduced from instant to instant in the facepiece of the mask. The per cent of gases in the facepiece of the mask is averaged by an integrating reservoir and indicates a trend, but this average is influenced by the inactive gases of the facepiece and anatomical dead space. In order to estimate the composition of inspired gases an indirect approach was used. This technique is based on the assumption that the end expiratory gases from the lungs have become mixed and represent a homogeneous mixture.

As an inert gas, nitrogen does not participate in metabolic exchange. If the absorption of O_2 and the production of CO_2 were exactly the same, the amount of nitrogen inspired would equal the amount expired; i.e., nitrogen molecules inspired = nitrogen molecules expired. The metabolic respiratory quotient (R.Q.) would equal one. The metabolic R.Q. $= \frac{CO_2 \text{ produced}}{O_2 \text{ consumed}}$ and is not normally equal to one, or unity. Under these conditions there may be a relative difference in the per cent of inert nitrogen inspired and expired. (The metabolic R.Q. depends upon the predominance of carbohydrates (1.0), protein (0.82) or fat (0.71) being metabolized). The normal value of a mixed diet approximates 0.83. The respiratory R.Q. may vary temporarily from the metabolic R.Q. due to unsteady states such as hyperventilation. The increased lung ventilation produces a blow-off of CO_2 from the blood and an apparent but misleading increase in CO_2 production with a resultant R.Q. greater than 1.0. Conversely, hypoventilation and retention of CO_2 indicate an apparent but misleading decrease in CO_2 production which results in an R.Q. less than 0.7.

One must keep in mind that the unequal exchange of oxygen and carbon dioxide involves only that portion of the gases consumed and produced. For example, if during a one-minute period at rest 0.3 liters of oxygen were consumed and 0.25 liters of CO_2 produced (R.Q. = 0.83), the resultant difference of 0.05 liters on the seven or eight liters passing through the lungs during the same period of time is relatively small. This produces an error of only a few per cent, well within the experimental error of the determinations of end expiratory nitrogen.

All nitrogen diluting the inspired gas originates from ambient air with the exception of nitrogen derived from the tissues which, after six to eight minutes of breathing oxygen under a steady state condition, has been shown to constitute less than one per cent of the lung volume.

Using calculations suggested by Luft[7], the admixture of air can be determined; i.e.:

$$\frac{\text{Admixture of air}}{100} = \frac{\text{Inspired nitrogen fraction}}{\text{Nitrogen fraction of air}}$$

By substituting end expiratory nitrogen for inspired nitrogen:

$$\text{Admixture of air} = \frac{\text{End expiratory nitrogen}}{\text{Nitrogen fraction of air}}$$

Using these formulas, the percentage of dilution, supply oxygen, oxygen from the ambient air, and total oxygen may be derived according to the following calculations:

$$\text{Per Cent Dilution} = \frac{\text{End expired } N_2 \times 100}{N_2 \text{ of air } (79.03)}$$

Oxygen from supply = 100 Per cent of dilution

Oxygen from ambient = Per cent dilution + oxygen from ambient

Total oxygen = oxygen from supply + oxygen from ambient

Calculated inspired oxygen partial pressure = $(P_B - 47)$ x Per cent total oxygen

Where: P_B = Total pressure in mm Hg at ambient altitude.

47 = Pressure, in mm Hg, of saturated water vapor at body temperature.

A Waters ear oximeter was affixed to the antihelix of the ear of each subject in order to obtain blood oxygen saturation under all conditions. A Statham pressure transducer was connected to the system in order to record the line pressure response of the regulator to altitude. Closed circuit television was utilized in order to monitor each subject's condition. Motion picture photography was also used to record the reservoir bag condition and volume. Instrumentation of the subjects is shown in Figure 5.

A bicycle ergometer was modified so that it could be operated by each subject while seated in an aircraft type seat. After the subject was instrumented and ground level baselines recorded, the chamber pressure was decreased to equivalents of 10,000 and 14,000 feet for recording of additional air breathing baselines. Chamber pressure was then increased to an equivalent of 8,000 feet in order to determine the subject's ability to equalize middle ear pressure. After the subject had donned the test mask, the chamber

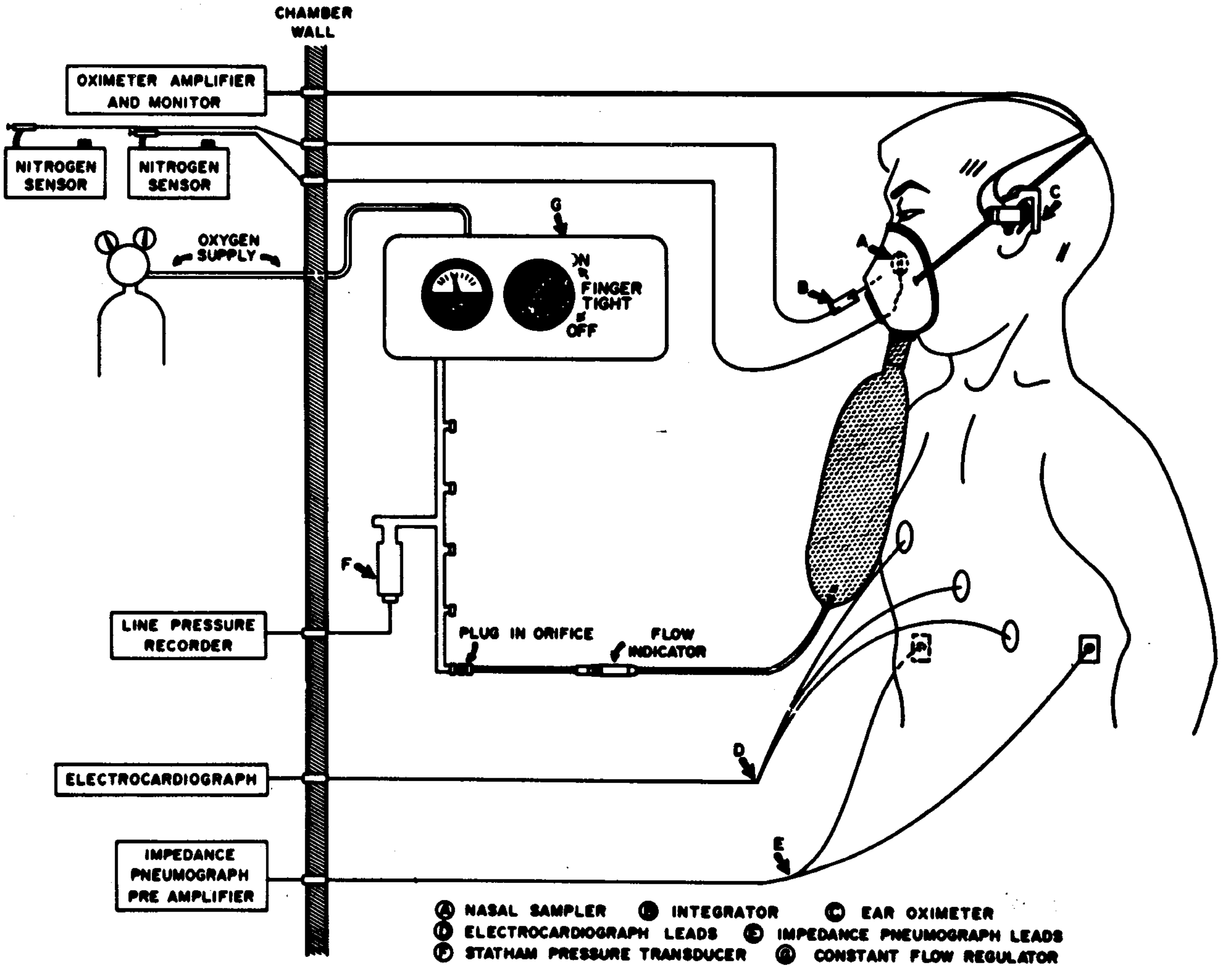

FIGURE 5.—Instrumentation of subjects and diagram of oxygen system.

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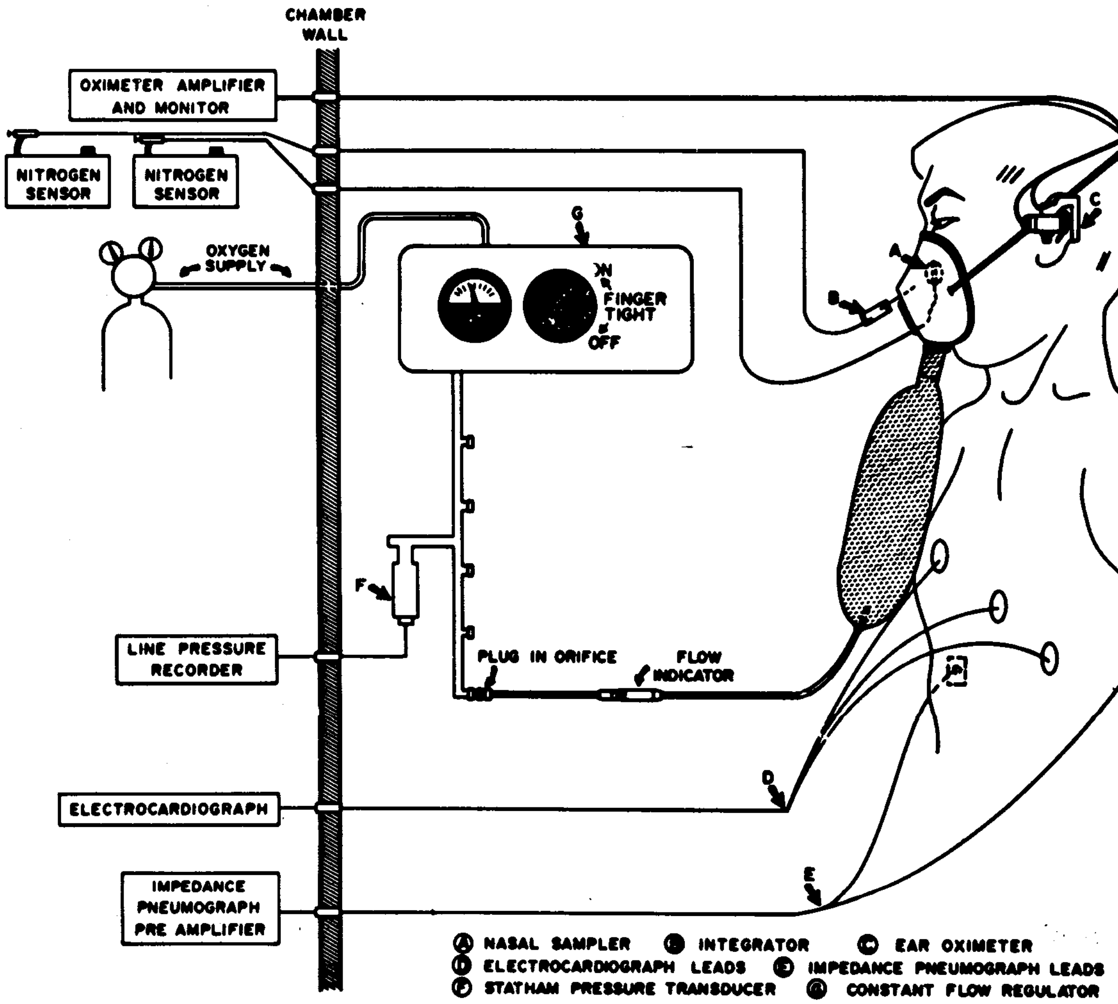

FIGURE 5.—Instrumentation of subjects and diagram of oxygen system.

pressure was decreased to equivalents of 14,000, 18,000, 25,000, 30,000 and 34,000 feet, leveling off at each altitude with the subject engaged in three-minute intervals of rest and light exercise at each altitude (Figure 6).

The bicycle ergometer was operated by each subject at 45 rpm and a workload setting of 45 watts, approximately equivalent to walking at a rate of 3.0–3.4 miles per hour on level terrain.

Oxygen flow provided to the mask is a function of the altitude response of the regulator which produces an increase in line pressure to fixed calibrated plug-in orifices incorporated in the mask hose. As altitude is increased, pressure and resultant flow to the mask are increased.

Oxygen flow, as provided by the regulator and orifices furnished with the mask, was determined by separately exposing the regulator to the same altitudes as the human subjects and recording the flow under standard conditions outside the chamber as shown in Figure 7. The capacity of the regulator to maintain pressure and resultant flow with a single as well as eight orifices connected to the system, was also dedetermined (Figures 8 and 9). Representative oxygen flow rates during the human subject tests with a single outlet in use are shown in the first portions of Tables 4 and 5.

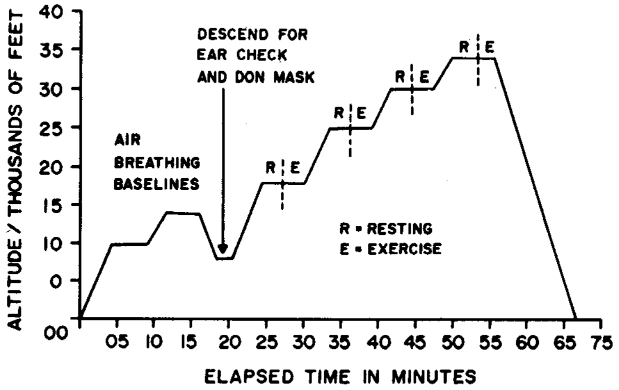

Figure 6.—Altitude chamber flight profile.

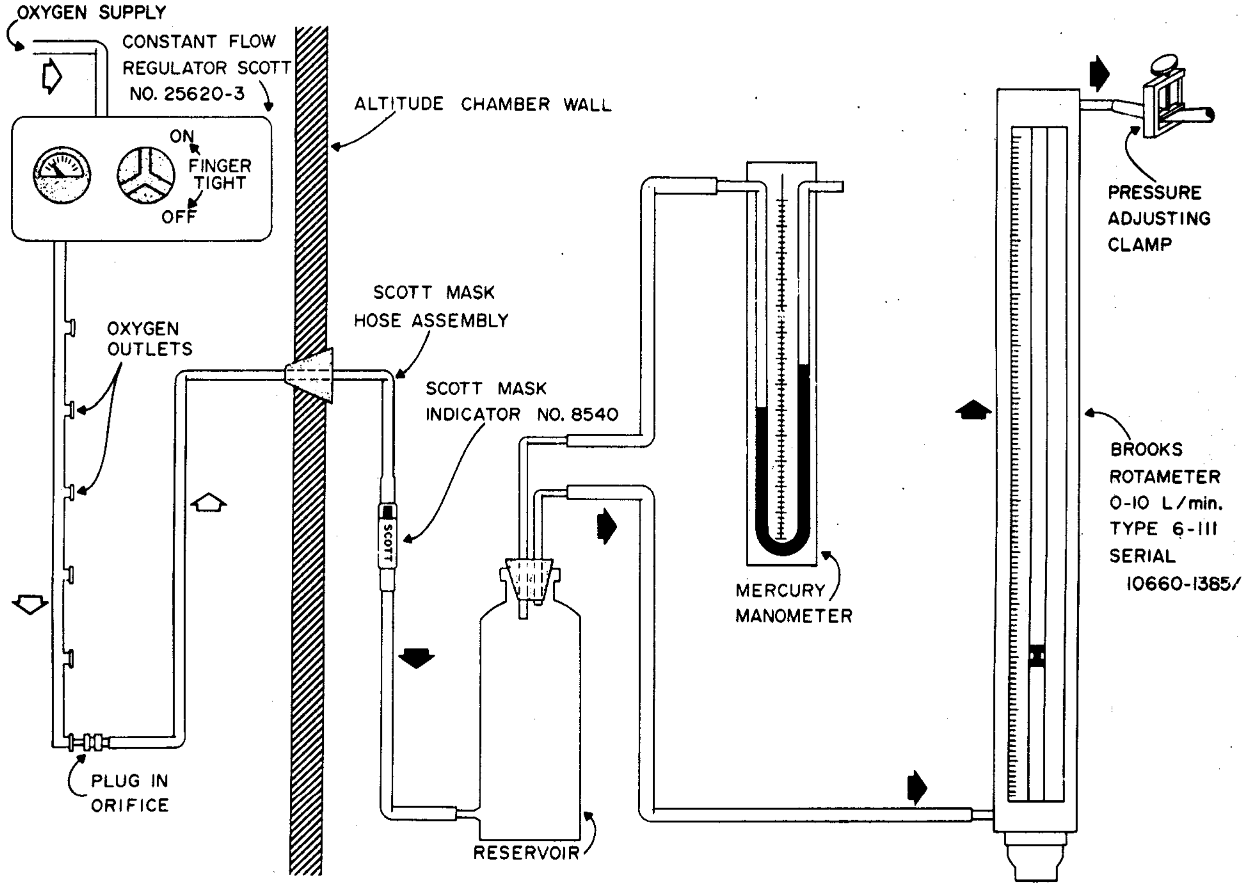

Figure 7.—Diagram of test method for determining flow characteristics of the automatic constant flow regulator and orifices. Regulator and outlets installed inside chamber and exposed to altitude.

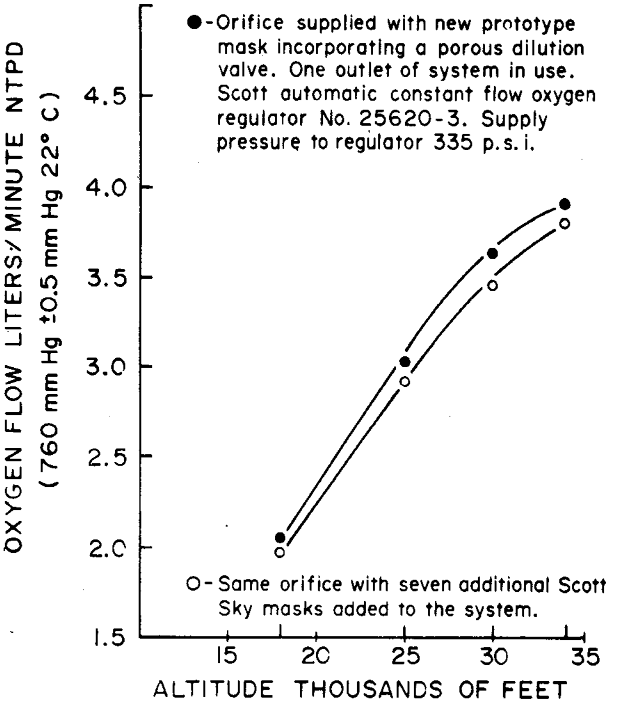

FIGURE 8.—Oxygen flow as determined by regulator and orifice as supplied with mask described above. Plot of data from Table IV.

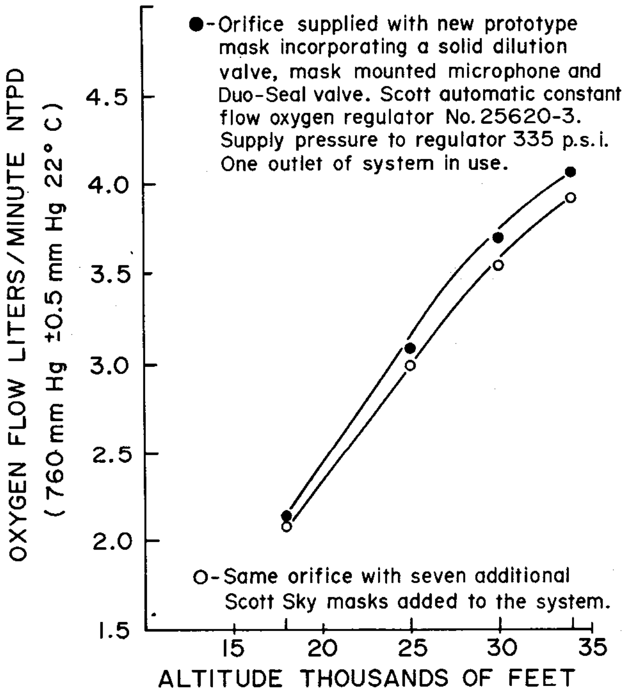

FIGURE 9.—Oxygen flow as determined by regulator and orifice as supplied with mask described above. Plot of data from Table V.

III. Results.

Oxygen flow as provided by the regulator was sufficient to maintain the subjects' indicated blood oxygen saturations well above their 10,000 and 14,000 feet baselines and equalled or exceeded their ground level (1,273 feet) baselines (Tables 1, 2 and 3). It should be emphasized that the masks were carefully fitted to the subjects to provide a good seal to the face. Additionally, all subjects were young, healthy males 24–38 years of age with previous high altitude experience.

From the standpoint of relative efficiency, calculated inspired oxygen partial pressures indicate that the phase dilution masks which incorporated either a porous dilution port or a dilution valve were comparable (Figures 10 and 11). The open dilution port mask produced lower tracheal oxygen partial pressures at all altitudes during rest and exercise. The effect of one minute of reading aloud was evaluated at 30,000 and 34,000 feet with this mask. This activity, due to high peak inspiratory flow rates and mask displacement, reduced the tracheal partial pressure to a greater extent than did exercise (Figure 11). However, since reading was limited to one minute, the reduced tracheal partial pressures did not appear to produce a significant effect upon the blood oxygen saturation.

The flows as provided by orifices furnished with the porous dilution port mask and solid dilution valve may be compared in Tables 4 and 5. Although the orifice furnished with the prototype mask incorporating a solid flutter type dilution valve provided slightly higher flow rates, this appears to be a function of manufacturing tolerance.

IV. Discussion.

The Scott Oxymatic automatic constant flow regulator when equipped with the proper orifices and efficient masks is designed automatically to provide sea level equivalents of oxygen flow to an altitude of 30,000 feet. Physiological evaluation of subjects at altitude indicated that the system, when utilized with new prototype rebreathing masks, maintained the subject's blood oxygen saturation and inspired tracheal oxygen partial pressure equal to or in excess of the ground level equivalent. Masks of this type provided higher and more consistent tracheal

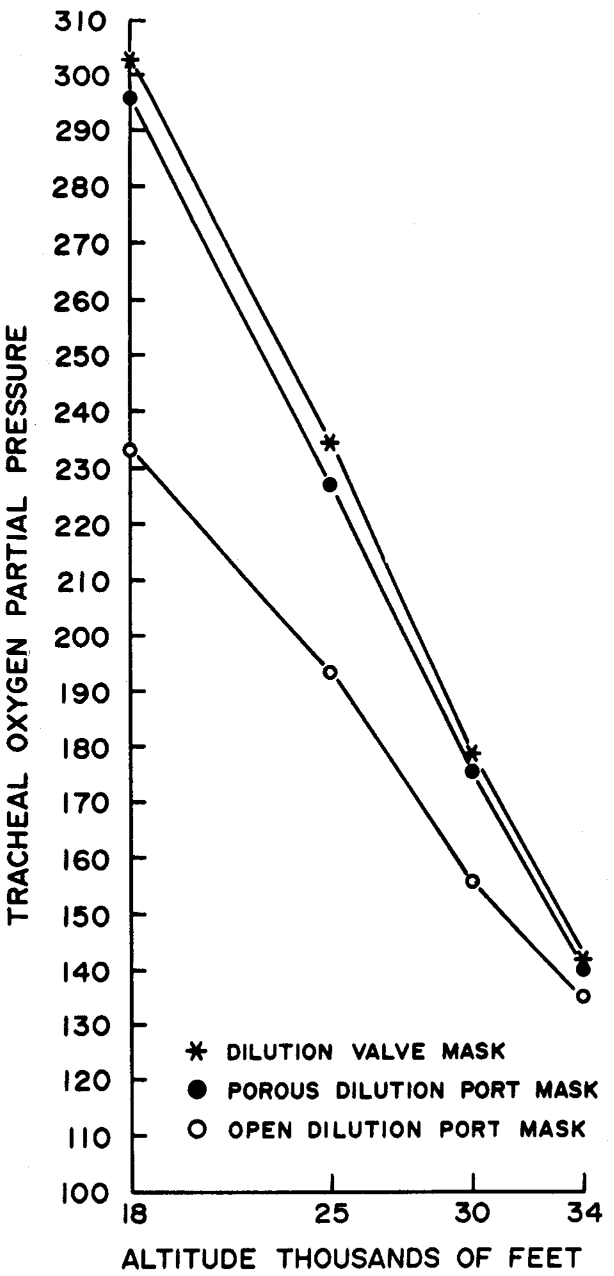

FIGURE 10.—Comparison of calculated resting tracheal oxygen partial pressures. Summary of data from Tables 1, 2 and 3.

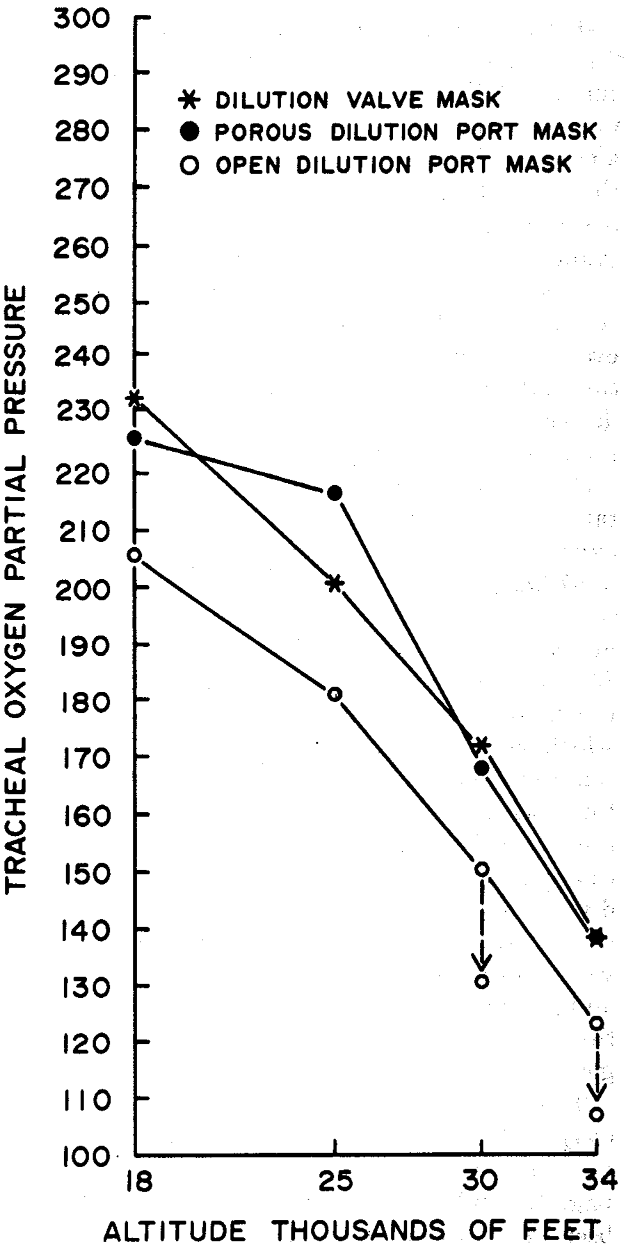

FIGURE 11.—Comparison of calculated tracheal oxygen partical pressures during exercise. Broken lines and arrows at 30,000 and 34,000 feet indicate magnitude of depression of tracheal oxygen partial pressure induced by high inspiratory flows characteristic of speech (reading). Summary of data from Tables 1, 2 and 3.

oxygen partial pressures than the similar mask equipped with open dilution ports. Had oxygen flows been lower it is anticipated that this difference would be exaggerated. In addition, if the tracheal oxygen partial pressure is reduced to a point approximating 90 to 100 mm Hg, hypoxic drive of respiration may ensue. In this case, a vicious cycle may develop when using constant flow diluter masks in that the mask wearer may reflexly hyperventilate. The increased ventilation results in more ambient air being drawn into the mask, diluting the oxygen, which in turn increases hypoxia and hyperventilation, continuing reduction of mask efficiency and resulting in an increased deterioration of the physiological condition of the mask wearer.

Hypoxic hyperventilation does not produce this same effect when air is breathed at, for example, 14,000 feet, since the inspired partial pressure remains constant. Similarly, at higher altitudes when demand oxygen equipment is used, the ratio of oxygen to air is accomplished by the demand regulator which is so designed and programmed that this ratio remains constant at a specific altitude regardless of the ventilation and respiratory activity of the mask wearer. However, with constant flow systems and masks, dilution ratios at a specific flow rate are largely determined by introduction of ambient air into the mask. Mask design, phase of the respiratory cycle in which dilution occurs, inspiratory flow rates and volume are the determiners of the oxygen/air ratios at a specific oxygen flow.

Although it was not measured, CO_2 accumulation in the rebreather bag did not appear to present a problem with the prototype masks. In previous mask evaluations it was found that the use of rapid response infra-red CO_2 analyzers which require relatively high sample flow rates compromised the determinations of end expiratory gases. Since the minimum required sample flow of 250 cc per minute represented a significant portion of the inspired gas, it could not be discarded but was returned by a closed circuit to the rebreather bag. However, as the sample was returned to the rebreather bag continuously and not in phase with the respiratory activity of the subject, measurement of other expiratory gases was rendered erratic and erroneous.

The respiratory center is very sensitive to CO_2 and it is anticipated that had significant quantities of CO_2 accumulated in the rebreather bag, the subject's respiratory rate would have been increased out of proportion to that expected for the degree of activity in which the subject was engaged. These data do not indicate this response.

It must be realized that these evaluations were carried out at altitude on young, healthy male subjects under favorable conditions with the masks correctly donned and providing a good fit to the face. Under actual conditions of use, care and caution may not be extended to this degree.

V. Summary and Conclusions.

1. Oxygen flow as provided by the Scott Oxymatic automatic constant flow regulator, when used in conjunction with either of the prototype phase dilution—rebreather test masks and proper orifices, was sufficient to maintain the subjects' indicated blood oxygen saturations equal to or in excess of their ground level (1,273 feet) baselines.

2. With the same oxygen flow rates the prototype porous and dilution valve masks provided higher tracheal oxygen partial pressures than the open port masks at all altitudes tested during rest and exercise.

3. The slight reduction of flow rates as provided by the Scott Oxymatic regulator when eight orifices were plugged into the system as opposed to one orifice is not considered to compromise significantly the performance of the system.

4. Heart and respiratory rates of all subjects indicate normal response, with the maximum generally occurring during exercise and hypoxia induced during establishment of air breathing baselines at 14,000 feet.

5. At the same flow rates a greater amount of oxygen was derived from the supply and less lost by the prototype phase-dilution rebreather masks as compared to the open port type mask.

TABLE 1. Physiological response of subjects wearing the new prototype version of the Scott Sky Mask incorporating a porous dilution valve. Flight profile as shown in Figure 1. Oxygen flow as determined by single metering orifice is shown in Table 4.

Subject	Activity	Altitude ft.	Resp. Rate	Heart Rate	Oximeter % Sat.	Line Pressure p.s.i.	% End Exp. N_2	% Dilution	% Oxygen From Supply	% O_2 From Ambient	Total % O_2 Supply + % Ambient	Barometric Pressure (P —47) mm Hg	Insp. O_2 Partial Pressure (P_b —47)x Total O_2
J. S.	Resting	Ground	15	69	97.0								
	Resting	10,000	20	81	89.3								
%N_2	Resting	14,000	20	76	85.5								
MEAN	Exercise	14,000	26	101	84.0								
15	Resting	18,000	12	74	97.0	53	8.0	10.0	90.0	2.0	92.0	333	306
38	Exercise	18,000	13	86	97.5	53	38.0	48.0	52.0	10.0	62.0	333	206
15	Resting	25,000	10	72	96.5	63	3.0	4.0	96.0	0.8	97.0	235	228
15	Exercise	25,000	15	87	98.0	63	6.0	8.0	92.0	1.6	94.0	235	221
10	Resting	30,000	9	79	97.6	69	4.0	5.0	95.0	1.0	96.0	179	172
10	Exercise	30,000	16	88	98.0	70	8.0	10.0	90.0	2.0	92.0	179	165
1	Resting	34,000	12	77	97.5	73	0.5	0.6	99.4	0.1	99.5	141	140
2	Exercise	34,000	15	90	98.0	73	0.5	0.6	99.4	0.1	99.5	141	140

Subject	Activity	Altitude ft.	Resp. Rate	Heart Rate	Oximeter % Sat.	Line Pressure p.s.i.	% End Exp. N_2	% Dilution	% Oxygen From Supply	% O_2 From Ambient	Total % O_2 Supply + % Ambient	Barometric Pressure (P —47) mm Hg	Insp. O_2 Partial Pressure (P_b —47)x Total O_2
P. F.	Resting	Ground	18	55	96.0								
	Resting	10,000	27	59	89.8								
%N_2	Resting	14,000	22	64	87.6								
MEAN	Exercise	14,000	35	93	86.0								
20	Resting	18,000	16	53	96.5	50	15.0	19.0	81.0	4.0	85.0	333	283
32	Exercise	18,000	28	71	97.0	50	26.0	33.0	67.0	6.9	74.0	333	246
8	Resting	25,000	16	55	97.0	60	4.0	5.0	95.0	1.0	96.0	235	226
13	Exercise	25,000	27	73	97.0	60	10.0	13.0	87.0	2.6	90.0	235	212
1	Resting	30,000	22	56	98.0	65	0.5	0.6	99.4	0.1	99.5	179	178
8	Exercise	30,000	25	72	98.0	66	4.0	5.0	95.0	1.0	95.9	179	172
3	Resting	34,000	16	60	99.0	72	1.0	1.0	99.0	0.3	99.0	144	140
3.5	Exercise	34,000	28	76	99.0	72	2.0	3.0	97.0	0.5	98.0	141	138

TABLE 2. Physiological response of subjects wearing a new prototype Scott mask incorporating a mask-mounted microphone and phase-dilution valve. Flight profile as shown in Figure 1. Oxygen flow as determined by single metering orifice is shown in Table 5.

Subject	Activity	Altitude ft.	Resp. Rate	Heart Rate	Oxi- meter % Sat.	Line Pres- sure p.s.i.	% End Exp. N_2	% Dilu- tion	% Oxygen From Supply	% O_2 From Am- bient	Total % O_2 Supply + % Am- bient	Baro- metric Pressure (P_2—47) mm Hg	Insp. O_2 Partial Pressure (P_b — 47)x Total O_2
C. H.	Resting	Ground	20	95	96.0								
	Resting	10,000	--	89	87.5								
%N_2	Resting	14,000	--	100	84.5								
Mean	Exercising	14,000	17	115	78.0								
13.0	Resting	18,000	14	85	97.0	52	9.0	11.4	88.6	2.4	91.0	333	303
27.0	Exercising	18,000	18	92	97.0	52	23.0	29.1	70.9	6.1	77.0	333	256
1.0	Resting	25,000	16	86	98.0	60	0.5	0.6	99.4	0.1	99.5	235	234
8.0	Exercising	25,000	19	96	98.5	62	2.5	3.2	96.8	0.7	97.5	235	229
0.0	Resting	30,000	17	87	99.0	69	0.0	0.0	100.0	0.0	100.0	179	179
1.0	Exercising	30,000	23	101	97.0	69	0.5	0.6	99.4	0.1	99.5	179	178
----	Resting	34,000	--	---	----	--	---	---	----	---	----	----	---
0.5	Exercising	34,000	22	105	99.0	72	0.2	0.3	99.8	0.1	99.8	141	141
G. F.	Resting	Ground	22	88	95.5								
	Resting	10,000	19	87	92.0								
%N_2	Resting	14,000	22	92	88.0								
Mean	Exercising	14,000	26	122	82.0								
12.0	Resting	18,000	20	81	97.5	52	9.0	11.4	88.6	2.4	91.0	333	303
40.0	Exercising	18,000	27	99	98.2	52	37.0	46.8	53.2	9.8	63.0	333	210
0.0	Resting	25,000	21	87	97.2	61	0.0	0.0	100.0	0.0	100.0	235	235
33.0	Exercising	25,000	24	107	98.0	61	26.0	33.0	67.0	7.0	74.0	235	174
1.0	Resting	30,000	19	89	97.2	69	0.5	0.6	99.4	0.1	99.5	179	178
13.0	Exercising	30,000	27	109	98.0	69	7.0	8.9	91.1	1.8	92.9	179	166
0.5	Resting	34,000	22	90	96.5	72	0.2	0.2	99.8	0.1	99.9	141	141
1.0	Exercising	34,000	29	106	97.2	72	0.5	0.6	99.4	0.1	99.5	141	140

TABLE 3. Physiological response of a subject wearing a Scott Sky Mask incorporating open dilution ports. Flight profile as shown in Figure 1 with the exception that for the first minute of each three minute resting period at 30 and 34,000 feet the subject was requested to read in order to evaluate the effect of speech upon mask performance. Oxygen flow as determined by the single metering orifice shown in Table 4.

Subject	Activity	Altitude ft.	Resp. Rate	Heart Rate	Oxi- meter % Sat.	Line Pres- sure p.s.i.	% End Exp. N_2	% Dilu- tion	% Oxygen From Supply	% O_2 From Am- bient	Total %O_2 Supply + % Am- bient	Baro- metric Pressure (P_2—47) mm Hg	Insp. O_2 Partial Pressure (P $_b$ —47)x Total O_2
C. B.	Resting	Ground	15	74	95.3								
	Resting	10,000	17	75	91.3								
%N_2	Resting	14,000	16	78	89.5								
MEAN	Exercising	14,000	20	99	83.3								
32	Resting	18,000	16	77	96.0	52	30	38.0	62.0	8.0	70.0	333	233
40	Exercising	18,000	19	92	96.5	53	38	48.1	51.9	10.1	62.0	333	206
22	Resting	25,000	17	78	96.0	62	18	22.8	77.2	4.8	82.0	235	193
25	Excerising	25,000	21	97	96.5	62	23	29.1	70.9	6.1	77.0	235	181
30	Reading	30,000	21	97	96.5	70	27	34.2	65.8	7.2	73.0	179	131
15	Resting	30,000	17	87	97.0	70	13	16.4	83.6	3.4	87.0	179	156
18	Exercising	30,000	20	96	96.2	70	16	20.2	79.8	4.2	84.0	179	150
26	Reading	34,000	19	102	95.5	74	24	30.4	69.6	6.4	76.0	141	107
9	Resting	34,000	18	82	97.2	74	4	5.0	95.0	1.0	96.0	141	135
15	Exercising	34,000	22	94	96.5	74	13	16.5	83.5	3.5	87.0	141	123

Table 4. Oxygen flow furnished by the Scott automatic constant flow regulator No. 25620-3 as measured at Normal Temperature Pressure Dry (NTPD) 22°C, 760 ± 0.5 mm Hg, using the orifice supplied with the new prototype version of the Scott Sky Mask. This mask incorporates a porous dilution valve. Automatic flow by increased pressure was activated by exposing the regulator to the indicated altitudes and measured as shown in Figure Seven. One outlet was used and the supply pressure maintained at 335 psi.

Altitude (Feet)	*Barometric Pressure mm. Hg.*	*Line Pressure p. s. i.*	*Flow L/Min NTPD*	*Calculated Flow L/Min BTPS*
0	760	40	0.00	
8,000	565	42	Less than 1.00	
18,000	380	58	2.05	4.93
25,000	282	71	3.02	10.28
30,000	226	74	3.63	16.23
34,000	188	78	3.95	22.44

Same orifice and conditions as above, but with seven additional Scott Sky Masks plugged into the system.

Altitude (Feet)	*Barometric Pressure mm. Hg.*	*Line Pressure p. s. i.*	*Flow L/Min NTPD*	*Calculated Flow L/Min BTPS*
0	760	41	0.00	
8,000	565	42	Less than 1.00	
18,000	380	58	1.98	4.77
25,000	282	70	2.92	9.94
30,000	226	74	3.46	15.47
34,000	188	78	3.82	21.70

Table 5. Oxygen flow furnished by the Scott automatic constant flow regulator No. 25620-3 as measured at Normal Temperature Pressure Dry (NTPD) 22°, 760 ± 0.5 mm Hg, using the orifice supplied with the prototype Scott mask. This mask incorporates a mask-mounted microphone and a phase dilution valve. Automatic flow by increased pressure was activated by exposing the regulator to the indicated altitude and measured as shown in Figure Seven. One outlet used and the supply pressure maintained at 335 psi.

Altitude (Feet)	*Barometric Pressure mm. Hg.*	*Line Pressure p. s. i.*	*Flow L/Min NTPD*	*Calculated Flow L/Min BTPS*
0	760	41		
8,000	565	44	Less than 1.00	
18,000	380	58	2.15	5.17
25,000	282	70	3.09	10.51
30,000	226	75	3.67	16.41
34,000	188	79	4.05	23.01

Same orifice and conditions as above, but with seven additional Scott Sky Masks plugged into the system.

Altitude (Feet)	*Barometric Pressure mm. Hg.*	*Line Pressure p. s. i.*	*Flow L/Min NTPD*	*Calculated Flow L/Min BTPS*
0	760	40		
8,000	565	43	Less than 1.00	
18,000	380	58	2.07	4.98
25,000	282	71	3.00	10.21
30,000	226	75	3.54	15.83
34,000	188	79	3.92	22.27

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