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Experimental Study on the Effects of Low
Barometric Pressures and Oxygen
Deprivation upon the Efficiency
of Mental and Physical Work.

By

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(with 2 plates.)

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Introductory.

In the premature days of the experimental psychology, there were some physiologists who investigated the effects of oxygen deprivation on the physiological functions, and while they were so engaged, some observations psychologically interesting were often made as by-products.

There are various methods of studying the effects of oxygen deprivation upon the mental and physical works. The first one is making use of balloons, airships, or aeroplanes. The second is to make experiments on the mountains or high land. The third is utilizing artificial devices of oxygen supply. (1, 2, 3, 4) Among these devices Henderson's Rebreathing Apparatus (5, 6), Flack's Bag (7) and Dreyer's devices of regulating oxygen supply (8) are the most convenient. The fourth is the chamber method, of which there are two kinds; one is the low oxygen chamber (9), and the other is the low pressure chamber (10). The purpose of the low oxygen chamber is to test the effects of diminished oxygen supply replacing it by nitrogen, leaving the whole pressure in the same degree as in the normal atmosphere. The low pressure chamber is one in which we can decrease both the pressure of the air and the amount of oxygen in the air just as if they were in some high altitudes. Of late, in many countries various investigations of the effects of oxygen deprivation are conducted in connection with aviation. They are making use of some of the above mentioned methods, but of them all Henderson's and Dreyer's methods as well as the chamber method are the most promising.

Experiments I.

The Effect of Changes of Barometric Pressures upon the Efficiency of the Mental and Physical Work.

I made five experiments for the purposes of my study. The first experiments was begun on the 19th of February, 1923 and the last one was completed on the 10th of July in the same year. The purpose of the first experiment was the examination of the effects of changes of barometric pressures upon the mental and physical works.

1. Kinds of Tests.


The tests selected for this experiment are the following five :

(1) Speed of Repeated Movements (Simple Card Sorting).

The materials used in this test were a box and fifty ordinary playing cards. The box is 45cm long and 8.5cm wide and is divided into five compartments each about 8cm wide with a board 5cm thick as the partition. The box is placed on the table in front of the subject and the cards are held in one of his hands. The subject is told to sort the cards one by one as fast as possible with the other hand, into each of the compartments beginning with the left one. The time spent for sorting these fifty cards is measured by a stop-watch.

(2) Speed of Repeated Choice Reaction (Complex Card Sorting).

A box and fifty ordinary playing cards are the materials for this test. The box is the same one as used in the first test, but on the side of each compartment, there is a card with one of these

five forms,  Each ten of the playing

cards have on the back, printed in black ink one of the same forms above mentioned. The subject is to hold the fifty cards in one hand and then sort them one by one with the other hand as quickly as possible into the compartment with the corresponding

form. The time for sorting them up is taken by a stop-watch and the number of mistakes are recorded. There are fifteen packs of these cards and precaution is taken so that each pack may have its own order of the forms, and that in the same pack the same forms may not come out in succession.

(3) Controlled Association (Ten Digits Addition).

Ten digits are typewritten vertically. The subjects are requested to add mentally and write down their sums under the columns. Each sheet has five columns. The time for finishing one sheet and the number of mistakes are recorded.

(4) Memorizing Letters. (Immediate Memory for Letters).

A card with consonant capitals typewritten in a line is exposed to view before the subject for a few seconds by the experimenter, and immediately after card is taken away, the subject is to write down the letters as he remembers. The number of the letters is 8, 10 or 12 as the case may be, and the time for exposure is from three to five seconds according to the qualification of the subject or the number of the letters.

(5) Strength of Grip.

By the Collins's dynamometer the grip strength of one hand of the subject is tested twice except in case of the subject *T* who was tested three times.

II. The Subjects of the Experiment.

The subjects participating in the experiment are six in all. Their initials will be used for description. Among them, *W* and *A* are English medical students of Oxford University. And both of them have had experience as aviators during the Great War. *E* is an American student studying law in the same university. *H* is a laboratory boy of the pathological laboratory. Both *M* and *T* are Japanese, the former is an assistant professor of gymnastics

of the Tokyo Teachers' College and the latter a professor of psychology of the same institution. Of these six subjects *H* being lefthanded was allowed to use his left hand, while the others used their right.

III. Results of Practice Experiments.

In order to increase the reliability of the results of the experiment, I arranged for each subject to have from seven to ten days' practice before the main experiment was begun, and the practice was carried out in the following ways:

(1) In the speed of Repeated Movements, they practised sorting fifty cards five times a day. The results of each day practice are shown in Table 1 in the appendix. A considerable individual difference was revealed in the absolute speed and improvement rate. For instance, the minimum of the improvement rate is 4.38 per cent and maximum 28.92 per cent.

(2) In the Repeated Choice Reaction, they practised five times a day with a pack of fifty cards. The average time (second) for sorting a pack, the mean variation of time, and the sum total of the mistakes for each day of practice are shown in Table 2 in the appendix. Here again we notice another remarkable case of individual difference. Generally speaking, the improvement rate in this test is greater than that in the repeated movement.

(3) In the Controlled Association I made them try thirty problems of the digit addition. The average time for each set of five problems, the mean variation and the sum total of the mistakes are shown in Table 3 in the appendix. The improvement rate is considered only as to time.

(4) In the test of Memorizing Letters the improvement rate can not be found, for I changed conditions every time of practice in order to determine the time of exposure and the number of

letters, suitable to each of the subjects. According to the results obtained, I determined to test *W*, *A* and *E* in the three cases of 8, 10 and 12 letters, giving three, four and five seconds for exposure respectively, and to test *H* in the two cases of 8 and 10 letters, giving five seconds for exposure for each of the tests, while I tested *M* and *T* in only one case of 8 letters, with five seconds for exposure.

(5) In Grip I had them all practice one hand five times a day, but *M* did ten trials every day. The results are given in table 4 in the appendix.

IV. The Low-Pressure Chamber and Its Equipment.

The low-pressure chamber in question is of the same type as the one described in the "Air Service Medical" pp. 343-345. It is a cylindrical steel tank, 678cm in diameter and 250cm high, standing on end. It is entered through a full-sized doorway in the side, and forms a commodious and comfortable room in which about five men may sit at a time. The reduction of pressure is brought about by means of a motor-driven vacuum pump. The pump withdraws air from the tank through a pipe at the top; at the same time the fresh air is admitted at the bottom, the amount of which is being regulated by a valve. The admission of air in this manner serves the double purposes of ventilating the chamber and of determining the rate at which the pressure is reduced. The inside of the chamber is painted white and lighted by tungsten daylight lamps. There are three windows of thick glass through which the experimenter, if he is outside, can observe the inside. When necessary, oxygen is supplied through the pipe in the wall leading into the chamber to a distributing board. The operator sits just before a small window, and on his right hand side there hangs a telephone which enables him to communicate with those

inside. At the right of the window a mercury manometre is provided to show the barometric pressure inside. On the left hand side of the operator are the valves regulating the oxygen supply, while the valves on his right hand side control the flow of air. Under the shelf before him is the switch for the motor. In this way the control of the operation of this apparatus is centralized, and the operator need not leave his post from the beginning to the end of an experiment. (Adapted from "Air Service Medical")

V. The Main Experiment

The object of this experiment is to find out how the decrease of the barometric pressure affects the efficiency of our mental and physical works. In order to investigate this problem I have made two kinds of experiments—the tank experiment and the control experiment.

The tank experiment consists of two series. First, the subject is tried on the tests in the normal barometric pressure. Then the operator starts pumping the air out to decrease the pressure in the tank at a rate equal to 1,000 feet rise a minute. And after pumping three minutes the same tests are given to the subject. In this way, the subject is tested every time when the pressure decreases equal to the height of 3,000 feet, until we reach the pressure equal to that at the height of 18,000 or 21,000 feet—the lowest barometric pressure for the subject in this experiment. This experiment is called the ascending series.

When the tests in the lowest pressure for the subject are finished, the operator starts to pump in the air this time to increase the pressure in the tank at a rate equal to 1,000 feet descent in a minute. In the course of increasing pressure the tests are repeated every time descending 3,000 feet, ending on the ground level. This one is called the descending series of the experiment.

In the control experiment the same kind of tests were carried out at the interval of three minutes as many times as in the tank experiment without changing the pressure of the air in the tank. The difference between the tank experiment and the control is that, while in the former there is decreasing or increasing of the air pressure, the latter has no change at all.

These two kinds of experiments were conducted in the following order :

- 1st day—The tank experiment,
- 2nd day—The control experiment,
- 3rd day—The control experiment,
- 4th day—The tank experiment.

I took care in arranging the order of the experiments as above, for I knew that the subjects had not yet reached their practice limit, though they extended their practice from 7 to 10 days, and I thought that the practice effect could be expected by the end of the whole experiments. Besides, I was afraid that even in one day's experiment the effect of the practice and especially of fatigue would show itself.

The tests were carried out in the following order : 1, repeating movement ; 2, choice reaction ; 3, controlled association ; 4, memorizing letters ; and 5, strength of grip.

For the subjects, *A* and *H*, the lowest barometric pressure in which they could be tested was equal to that at a height of 18,000, while the other four subjects were tested in the pressure equal to that at a height of 21,000 feet.

VI. Results of the Experiment.

The results of the experiment will be described in the order of the tests.

- (1) Repeated Movements (Simple Card Sorting). In this test

I made the subject sort 50 cards into the due compartments of the box in the way explained before and measured the time wanted for the test. During the test two kinds of mistakes were often noticed. One was sorting two cards into one compartment at a time, and the other dropping the card outside of the compartment. There were more mistakes in the former than in the latter.

TABLE I.

Changes of Pressures and Speed of Repeated Movements.
(Subj. *W.*)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	17.0	17.0	17.0	100.00	0,000	16.8	16.2	16.5	100.00	0
2	16.8	16.0 ¹	16.7	98.24	3,000	17.2	16.2	16.7	101.21	+ 2.97
3	17.0	17.0	17.0	100.00	6,000	16.5	17.0 ¹	17.0	103.03	+ 3.03
4	16.2	17.5	16.9	94.41	9,000	17.0	17.8	17.4	105.45	+ 6.04
5	16.8	17.0	16.9	99.41	12,000	17.5 ¹	16.0	17.0	103.03	+ 3.62
6	15.8	16.8	16.3	95.88	15,000	18.2	16.2	17.2	104.02	+ 8.14
7	16.5	16.0	16.3	95.88	18,000	20.0	16.5 ¹	18.5	112.12	+ 16.24
8	16.0	16.8	16.4	96.47	21,000	20.0 ²	17.5 ¹	19.5	118.02	+ 21.55
9	16.2	16.8	16.5	97.06	18,000	17.5	19.5 ¹	18.8	113.94	+ 16.88
10	15.8	16.5	16.2	95.29	15,000	16.0	18.0 ¹	17.0	103.03	+ 7.74
11	16.8	16.8	16.8	98.82	12,000	16.5	18.0 ¹	17.5	106.06	+ 7.24
12	15.8	16.8	16.3	95.88	9,000	17.0	16.5	16.8	101.82	+ 5.94
13	15.0	16.2	15.6	91.76	6,000	16.0	15.8	15.9	96.36	+ 4.60
14	16.0	17.2	16.6	97.65	3,000	16.0	16.5	16.3	98.79	+ 1.14
15	17.0	16.0	16.5	97.06	0,000	16.2	16.5	16.4	99.41	+ 2.36

Table I is the result obtained by the subject *W*. In this table the results of the tank and control experiments are shown separately. Both show the results of the test in two cases. The figures under the Roman numerals I and II in the table indicate the number of seconds wanted for the test and the smaller ones by them, the number of mistakes. The average is that of seconds required for two trials, and 0.5 second is added for penalty for each mistake. In the column of percentage, 100 is given for the time required for the first test on the ground level, and the time spent for the rest is shown by its percentage. The "difference" means that between the percentage in the control experiment and that in the tank experiment, and when the difference in the former is larger than that in the latter, the sign - is put before the figures showing the difference, but when the contrary is the case, the sign + is put instead.

The results of the other five subjects are given in the tables 5 to 9 in the appendix. The figures with an asterisk in the fifth and seventh tables in the appendix mean assumed numbers, for the subjects, *E* and *T* became unconscious or almost senseless during the tests when the pressure was lowered to the degree of that at a height of 21,000 feet, and no record was available. But the numbers are not groundless. They were calculated by the following process, taking into consideration the results of the other tank experiments. As an example I will now take the subject *E*'s case in table 5 in the appendix. (1), I get first the sum total seconds 338.8 of all the fourteen cases except that at the height of 21,000 feet in the tank experiment I, (2) then the sum total seconds 301.1 of the fourteen cases in the tank experiment II, (3), by comparing these two figures I find that the percentage of the result of the second tank experiment against that of the first one is 88.87. And 88.87 per cent of 28.0 seconds,

which is the result of the test made at a pressure of 21,000 feet in the first tank experiment, is 24.9 seconds. I took this number as one for the gap in the second experiment. All the following assumed numbers have been found in the same way.

The results of the four subjects *W*, *E*, *M*, and *T* who were tested up to the height of 21,000 feet and those of the other two subjects *A* and *H*, who were tested up to that at the height of 18,000 feet, are summed up separately and shown in table II.

TABLE II.

Changes of Pressures and Deficiency in Repeated Movements.

Feet	Subjects				Av.	Subjects		Av.
	W	E	M	T		A	H	
3,000	+ 2.97	+ 3.18	- 3.55	+ 3.33	+ 1.48	- 1.01	+ 1.60	+ 0.30
6,000	+ 3.03	+ 2.73	+ 0.50	+ 2.14	+ 2.10	+ 1.59	+ 6.40	+ 4.00
9,000	+ 6.04	+ 6.38	+ 3.55	+ 4.31	+ 5.07	+ 2.11	+ 2.13	+ 2.12
12,000	+ 3.62	+ 6.38	+ 5.07	+ 1.07	+ 4.07	+ 2.11	+ 3.75	+ 2.93
15,000	+ 8.14	+ 5.01	+ 6.08	+ 3.78	+ 5.50	+ 4.79	+ 4.27	+ 4.53
18,000	+ 16.24	+ 9.10	+ 13.20	+ 21.08	+ 14.91	+ 16.72	+ 13.92	+ 15.32
21,000	+ 21.55	+ 23.19	+ 15.73	+ 26.50	+ 21.74	—	—	—
18,000	+ 16.88	+ 18.62	+ 13.18	+ 19.47	+ 17.04	—	—	—
15,000	+ 7.74	+ 10.93	+ 9.64	+ 12.43	+ 10.19	+ 13.23	+ 11.13	+ 12.18
12,000	+ 7.24	+ 9.12	+ 9.11	+ 4.35	+ 7.46	+ 9.92	+ 3.21	+ 6.57
9,000	+ 5.94	+ 5.92	+ 8.10	+ 3.26	+ 5.81	+ 5.83	+ 2.68	+ 4.26
6,000	+ 4.60	+ 6.39	+ 5.55	+ 6.49	+ 5.76	+ 5.70	+ 1.61	+ 3.66
3,000	+ 1.14	+ 5.94	+ 5.57	+ 5.95	+ 4.65	+ 9.09	+ 1.61	+ 5.35
0,000	+ 2.36	+ 5.04	+ 5.55	+ 2.19	+ 3.73	+ 1.15	+ 4.81	+ 2.98

TABLE III.

Changes of Pressures and the Deficiency in Choice Reaction.

Feet	Subjects				Av.	Subjects		Av.
	W	E	M	T		A	H	
3,000	+ 3.89	+ 0.37	+ 0.62	- 1.32	+ 0.89	- 0.65	+ 4.89	+ 2.12
6,000	+ 4.66	+ 1.49	+ 4.32	+ 1.00	+ 2.87	+ 6.47	+ 6.54	+ 6.51
9,000	+ 3.51	+ 2.95	+ 2.42	+ 4.29	+ 3.29	+ 5.39	+ 3.49	+ 4.44
12,000	+ 5.47	+ 2.23	+ 2.15	+ 4.27	+ 3.53	+ 9.17	+ 3.83	+ 6.50
15,000	+ 9.76	+ 6.77	+ 8.01	+ 7.24	+ 7.95	+15.23	+ 5.53	+10.38
18,000	+15.65	+20.59	+10.80	+24.67	+17.93	+41.42	+33.36	+37.39
21,000	+26.60	+80.50	+17.27	+46.39	+42.67	—	—	—
18,000	+14.06	+46.05	+18.82	+16.45	+32.85	—	—	—
15,000	+16.42	+19.92	+ 8.31	+ 6.91	+12.89	+35.68	+ 9.64	+22.66
12,000	+ 7.07	+ 8.64	+ 5.53	+ 2.26	+ 5.88	+ 8.88	+ 9.37	+ 9.13
9,000	+ 5.48	+ 2.62	+ 8.02	+ 1.31	+ 4.36	+ 6.02	+ 5.91	+ 5.97
6,000	+ 4.71	+ 3.03	+ 6.47	+ 3.28	+ 4.37	+ 3.79	+ 9.63	+ 6.71
3,000	+ 1.98	+ 1.88	+ 6.28	+ 3.98	+ 3.52	+ 4.42	+ 4.54	+ 4.48
0,000	+ 3.91	+ 4.53	+ 4.91	+ 2.30	+ 3.81	+ 2.83	+ 2.10	+ 2.47

(2), Choice Reaction (Complex Card Sorting).

In this test fifty cards were sorted out into five sets consisting of ten cards each. In this case also I measured the time wanted for the work and counted those cards thrown into wrong compartments by mistake. The tables from 10 to 15 in the appendix show the results got by each subject, and the smaller figures beside the numbers showing time are the numbers of the mistakes. The average is the result calculated by adding one second for each mistake. In other respects, they refer to just the same

things as in the first table. The results of the two groups put together are shown in Table III.

(3), Controlled Association (Ten digits addition).

In this test I made the subjects sum up five addition sums each time, measured the time spent for each sum and recorded the number of mistakes made in it. The results thus obtained are arranged in three ways as follows:

TABLE IV.

Changes of Pressures and Speed of Addition.

Feet	Subjects				Av.	Subjects		Av.
	W	E	M	T		A	H	
3,000	+ 6.44	+ 1.59	- 4.47	- 3.70	- 0.04	+ 6.33	+ 8.05	+ 7.19
6,000	+ 7.87	+ 5.56	+11.11	+ 4.18	+ 7.18	+ 8.98	+ 7.50	+ 8.24
9,000	+ 3.33	+12.12	+ 2.71	+ 2.89	+ 5.26	+12.63	+ 2.14	+ 7.39
12,000	+ 9.26	+ 9.96	+ 2.35	+17.64	+ 9.80	+20.00	+ 5.33	+12.67
15,000	+ 7.40	+11.81	+13.02	+ 7.86	+10.02	+25.76	+23.40	+24.58
18,000	+15.19	+45.55	+17.37	+50.95	+32.27	+53.67	+37.74	+45.71
21,000	+20.37	+207.93	+134.28	+85.48	+112.02	—	—	—
18,000	+14.81	+90.30	+26.35	+53.25	+46.18	—	—	—
15,000	+ 9.26	+29.69	+19.65	+21.95	+20.14	+30.88	+12.35	+21.62
12,000	+14.07	+ 5.31	+ 7.80	+ 7.52	+ 8.68	+17.96	+12.11	+15.04
9,000	+10.00	+17.15	+16.54	+13.06	+14.19	+19.11	+ 9.10	+14.11
6,000	+10.74	+10.33	+ 8.77	+15.93	+11.44	+13.64	+13.83	+13.74
3,000	+ 1.85	+14.77	+ 8.18	+ 1.57	+ 6.58	+17.22	+ 2.34	+ 9.78
0,000	+ 1.11	+11.87	+ 3.74	+ 4.18	+ 5.23	+12.26	+11.11	+11.69

(A) First, the number of seconds required for adding are simply compared one with another without any reference to mistakes. The results are shown in Tables 16 to 21 in the appendix. The smaller figures in the tables mean the number of the mistakes. In Table IV the results obtained by two groups are separately calculated and shown.

TABLE V.
Changes of Pressures and Frequency of Mistakes in Addition.

Tests	Control Exp.								Total	Feet	Tank Exp.								Total
	W		E		M		T				W	E	M	T					
	I	II	I	II	I	II	I	II							I	II	I	II	
1					I	I			2	0,000			I				I		2
2	I	I			I				3	3,000	I	I							2
3	I			I				I	3	6,000							I		1
4			I	I					2	9,000									0
5		I					I	I	3	12,000			I				I		2
6					I		I		2	15,000			I		I		I		3
7		I						I	2	18,000	I	I	4	I			2	2	11
8			I	I	I				3	21,000	3	2	4	2	2	5	3	3	24
9	I		2			I	I		5	18,000	I	I	I	2			2	2	9
10		I							1	15,000	3		I				I		5
11			I	I					2	12,000			I	I				I	3
12									0	9,000			2			I			3
13	I	I					I		3	6,000				I	I				2
14	I	I							2	3,000								I	1
15	I	I	I	I	I				5	0,000	2						I		3
Total	13		11		6		8		38	Total	16		22		11		22		71

TABLE VI.

Changes of Pressures and Frequency of Mistakes in Addition.

Tests	Control Exp.					Feet	Tank Exp.				
	A		II		Total		A		II		Total
	I	II	I	II			I	II	I	II	
1	I	I	2	I	5	0,000		I	I		2
2		I	I	I	3	3,000	I	I	2		4
3				2	2	6,000			I		1
4				I	1	9,000			2		2
5				I	1	12,000			3		3
6		I		2	3	15,000		2	2	I	5
7	I				1	18,000	2	3	3	4	12
8		I			1	15,000	2	I	2	3	8
9					0	12,000				I	1
10			I		1	9,000				I	1
11			I		1	6,000	I	I	2	I	5
12		I	2	I	4	3,000			I	I	2
13	I	I	I		3	0,000		I		2	3
Total	3	6	8	9	26	Total	6	10	19	14	49

(B) When we calculate only the number of mistakes regardless of time required for adding we have Tables V and VI. Compare these tables from IV to VI and you will find that the speed of calculation suddenly lessens and the number of mistakes markedly increases at the height of 18,000 feet and above. The same fact has also been clearly seen in Tables II and III. Now, we restrict our observation to the number of mistakes only, and then we notice in Table V that the number of mistakes in the tank

experiments is 71 against the sum total 38 in the control experiments, that is there are 33 more mistakes, an increase of 86.84 per cent against 38. And this remarkable increase of mistakes takes place chiefly in the tests conducted at the height between 18,000 feet and 21,000 feet in the descending series. Such is the case with Table VI; in that table the number of the mistakes in the tank experiment is 49 to 26 in the control one, showing the difference of 23 which means the increase of 88.69 per cent. And this fact comes under notice chiefly in the descending series below 18,000 feet.

TABLE VII.
Changes of Pressures and Deficiency in Addition (%)
(Time added for mistakes)

Feet	Subjects				Av.	Subjects		Av.
	W	E	M	T		A	H	
3,000	+ 4.81	+ 6.96	- 4.97	- 3.57	+ 0.81	+13.99	+18.37	+16.18
6,000	+ 2.87	+ 3.85	+15.84	+ 5.15	+ 6.93	+12.23	+12.01	+12.12
9,000	+ 1.48	+ 0.77	+ 7.56	+ 2.69	+ 3.13	+15.18	+16.25	+15.72
12,000	+10.00	+ 2.08	+ 1.88	+16.05	+ 7.50	+22.27	+24.90	+23.59
15,000	+ 2.52	+ 6.71	+19.64	+ 7.64	+ 9.13	+33.23	+40.76	+37.00
18,000	+22.59	+83.30	+21.87	+70.32	+49.52	+85.33	+89.09	+87.21
21,000	+50.00	+285.58	+216.74	+131.33	+170.91	—	—	—
18,000	+17.41	+101.80	+26.23	+74.04	+54.87	—	—	—
15,000	+20.63	+34.99	+24.65	+26.18	+26.61	+47.75	+47.18	+47.47
12,000	+21.49	+ 4.60	+12.48	+12.43	+12.75	+22.27	+23.82	+23.05
9,000	+15.55	+30.34	+27.49	+12.36	+21.44	+21.87	+17.21	+19.54
6,000	+ 0.37	+ 8.99	+24.37	+ 6.46	+10.05	+28.54	+34.17	+31.36
3,000	- 3.75	+16.45	+12.91	+ 6.16	+ 7.94	+14.87	+ 6.90	+10.89
0,000	+ 6.67	+ 0.24	+ 3.83	+ 8.68	+ 4.86	+10.05	+24.34	+17.20

(C) Lastly, the difference between the seconds wanted for the control experiment and those for the tank experiment in their percentage is shown in Table VII, and in the calculation of them one tenth of the time wanted for the solution of one problem was added for each mistake. By that table we find that the general tendency is similar to that seen in the fourth table, and besides, as the number of mistakes is taken into consideration in the calculation in this case, the tendency of a sudden decrease in efficiency after a certain pressure is attained is shown more clearly.

TABLE VIII.
Changes of Pressures and Memory (%)

Feet	Subjects				Av.	Subjects		
	W	E	M	T		A	II	
3,000	+ 3.36	- 2.60	+ 0.10	+ 2.65	+ 0.88	+ 0.14	+ 3.12	+ 1.63
6,000	- 7.93	+ 9.02	+ 6.40	+ 3.85	+ 2.84	- 9.82	+ 3.25	- 3.29
9,000	- 17.21	- 2.60	- 2.46	- 6.63	- 7.23	- 7.67	+ 3.20	- 5.44
12,000	- 3.49	- 3.80	—	- 5.46	- 3.25	- 1.96	- 1.59	- 1.78
15,000	- 7.14	- 1.88	- 11.09	- 10.88	- 7.75	+ 10.75	- 3.18	- 6.79
18,000	- 17.49	- 1.76	- 1.84	- 9.44	- 7.63	- 10.78	- 30.62	- 20.70
21,000	- 24.41	- 39.73	- 27.77	- 30.23	- 30.71	—	—	—
18,000	- 22.01	- 6.49	- 12.68	- 13.86	- 13.76	—	—	—
15,000	- 8.36	- 4.49	- 3.94	- 5.88	- 5.67	- 7.72	- 5.90	- 6.81
12,000	- 5.97	- 11.76	—	- 3.05	- 6.93	- 5.94	- 5.86	- 5.90
9,000	- 4.79	+ 3.57	- 0.61	- 11.88	- 3.43	- 6.78	- 0.02	- 3.40
6,000	- 3.49	+ 2.78	- 2.09	- 1.76	- 1.14	- 1.98	- 6.55	- 4.27
3,000	+ 4.56	+ 0.78	- 7.24	- 2.69	- 1.54	- 0.98	+ 1.64	+ 0.33
0,000	+ 3.38	- 5.33	+ 2.12	+ 1.23	+ 0.35	- 6.00	+ 0.18	- 2.91

TABLE IX.
Change of Pressures and Grips (%)

Feet	Subjects				Av.	Subjects		Av.
	W	E	M	Av.		A	H	
3,000	+ 0.63	+ 0.82	- 0.27	- 1.08	+ 0.03	- 2.91	- 1.20	- 2.06
6,000	- 0.88	- 1.68	+ 1.87	- 2.26	- 0.74	- 0.51	- 2.99	- 1.75
9,000	- 1.60	+ 1.60	+ 3.40	- 1.13	+ 0.58	- 3.83	- 3.87	- 3.85
12,000	- 0.64	+ 0.83	+ 3.41	- 1.51	+ 0.52	+ 3.66	- 2.21	+ 0.75
15,000	- 1.97	+ 0.19	+ 3.57	- 3.06	- 0.32	+ 3.14	- 3.72	- 0.29
18,000	- 1.27	- 3.05	+ 2.64	- 3.71	- 1.35	+ 1.05	- 0.07	+ 0.49
21,000	- 1.90	- 4.31	- 5.99	- 5.70	- 4.48	—	—	—
18,000	- 1.27	- 3.14	- 0.26	- 6.53	- 2.80	—	—	—
15,000	- 2.62	- 2.08	- 2.94	- 1.61	- 2.31	- 1.21	- 0.53	- 0.87
12,000	- 1.18	- 4.56	- 1.10	- 1.16	- 1.75	- 0.45	+ 0.16	+ 0.31
9,000	- 1.42	+ 0.01	- 0.48	- 0.79	- 0.67	- 0.80	- 3.21	- 2.01
6,000	- 1.42	- 0.42	- 3.47	- 2.09	- 1.85	- 0.80	+ 0.87	+ 0.04
3,000	+ 0.08	- 2.66	- 3.30	- 1.30	- 1.40	- 3.61	+ 0.16	- 1.73
0,000	- 0.08	- 2.76	- 2.93	- 0.38	- 1.54	- 1.83	+ 0.98	- 0.43

(4) Memory Test.

In this test, as it was explained before about the practice experiment, both the number of letter given as stimuli and the time of exposure were varied for each subject. But in any case, if I sum up the results, giving two marks for the letters in their right places and one mark for those in the wrong ones, I obtain Tables 22 to 27 in the appendix. Table VIII is one in which the differences of percentage are put together. In this case marks obtained being compared, (+) shows that the result in the result in the tank experiment is better than that in the control experi-

ment, while (—) shows that the efficiency in the tank is lower than in the other. In this experiment, the fluctuation is more remarkable than in the others, yet the general tendency seen in the results is quite the same as in the other tests mentioned heretofore.

TABLE X.

Changes of Pressures and Comparison of Efficiency
in various kinds of Tests.
(Subjects, *W*, *E*, *M* and *T*.)

Feet	Repeated Move	Choice Reaction	Addition (Time)	Memory	Grips
3,000	+ 1.48	+ 0.89	- 0.04	+ 0.88	+ 0.03
6,000	+ 2.10	+ 2.87	+ 7.18	+ 2.84	- 0.74
9,000	+ 5.07	+ 3.29	+ 5.26	- 7.23	+ 0.58
12,000	+ 4.04	+ 3.53	+ 9.80	- 3.25	+ 0.52
15,000	+ 5.50	+ 7.95	+ 10.02	- 7.75	- 0.32
18,000	+ 14.91	+ 17.93	+ 32.27	- 7.63	- 1.35
21,000	+ 21.74	+ 42.67	+ 112.02	- 30.71	- 4.48
18,000	+ 17.04	+ 23.85	+ 46.18	- 13.76	- 2.80
15,000	+ 10.19	+ 12.89	+ 20.14	- 5.67	- 2.31
12,000	+ 7.46	+ 5.88	+ 8.68	- 6.93	- 1.75
9,000	+ 5.81	+ 4.36	+ 14.19	- 3.43	- 0.67
6,000	+ 5.76	+ 4.37	+ 11.44	- 1.14	- 1.85
3,000	+ 4.65	+ 3.52	+ 6.58	- 1.54	- 1.40
0,000	+ 3.79	+ 3.81	+ 5.23	+ 0.35	- 1.54

(5) Strength of Grips.

As for the strength of grips, every subject was tested twice on each occasion except *T* whose grip was measured thrice each time. The left-handed *H* was tested with his left hand. The

results for each subject are shown in Tables 28 to 33 in the appendix. Here again, as in the memory test the figures with (—) indicate the decrease of efficiency and those with (+) the increase of the same. Table IX shows the summed-up results of the two groups calculated separately. What we find remarkable in this table is that the variation of the strength of grips relating to the change of the air pressure is very unsettled, while there is not much decrease of the strength of grips even at a height of 21,000 feet where the pressure of the air is the lowest in this experiment.

TABLE XI.

Changes of Pressures and Comparison of Efficiency
in various kinds of Tests.

(Subjects *A* and *H*)

Feet	Repeated Move.	Choice Reaction	Addition (Time)	Memory	Grips
3,000	+ 0.30	+ 2.12	+ 7.19	+ 1.63	— 2.06
6,000	+ 4.00	+ 6.51	+ 8.24	— 3.29	— 1.75
9,000	+ 2.12	+ 4.44	+ 7.39	— 5.44	— 3.85
12,000	+ 2.93	+ 5.63	+ 12.67	— 1.78	— 0.73
15,000	+ 4.53	+ 10.38	+ 24.58	— 6.79	— 0.29
18,000	+ 15.32	+ 37.39	+ 45.71	— 20.70	+ 0.49
15,000	+ 12.18	+ 22.66	+ 21.62	— 6.81	— 0.87
12,000	+ 6.57	+ 9.13	+ 15.04	— 5.90	+ 0.31
9,000	+ 4.26	+ 5.97	+ 14.11	— 3.40	— 2.01
6,000	+ 3.66	+ 6.71	+ 13.74	— 4.27	+ 0.04
3,000	+ 5.35	+ 4.48	+ 9.78	+ 0.33	— 1.73
0,000	+ 2.98	+ 2.49	+ 15.69	— 2.91	— 0.43

(6) The Conclusion.

So far we have separately observed various features of each test. For the sake of convenience of our observation, I shall now show you Tables X and XI, in which the average results of Tables II, III, IV, VIII and IX are arranged according to the groups, *A* and *H* on one hand and *W*, *E*, *M* and *T* on the other, (those figures with (+) in repetition, choice and addition mean increase of time for work; that is decrease in efficiency, but in memory and strength the figures with the same sign mean increase in efficiency). And again those results in Tables X and XI are shown in curves drawn in Figures 1 and 2. In these figures you will find that, (1) the curves in all tests descend gradually until they reach the height of 15,000 feet, where they begin to descend quite suddenly, and at the height of 18,000 or 21,000 feet at which the air pressure was the lowest in these tests the decreasing rate will reach its maximum, and in the descending series the restoring rate increases suddenly at the height of 18,000 feet and downward.

(2) The general tendency of both the ascending and descending series resembles each other, yet as a rule the efficiency in the latter is inferior to the former even in the same air pressure. This may mean perhaps that the effect given upon the subjects in the course of the experiment of the ascending series still remains in the experiment of the descending series.

(3) There are differences in the decreasing rates according to the kinds of tests. The smallest decreasing rate is that of the strength of grips and the largest is that of addition, while the rest is found between these two. Comparing the repeating movement with the choice reaction we find that the decreasing rate of the latter is generally greater than that of the former.

Thus, generally speaking it may be said that the effect of the

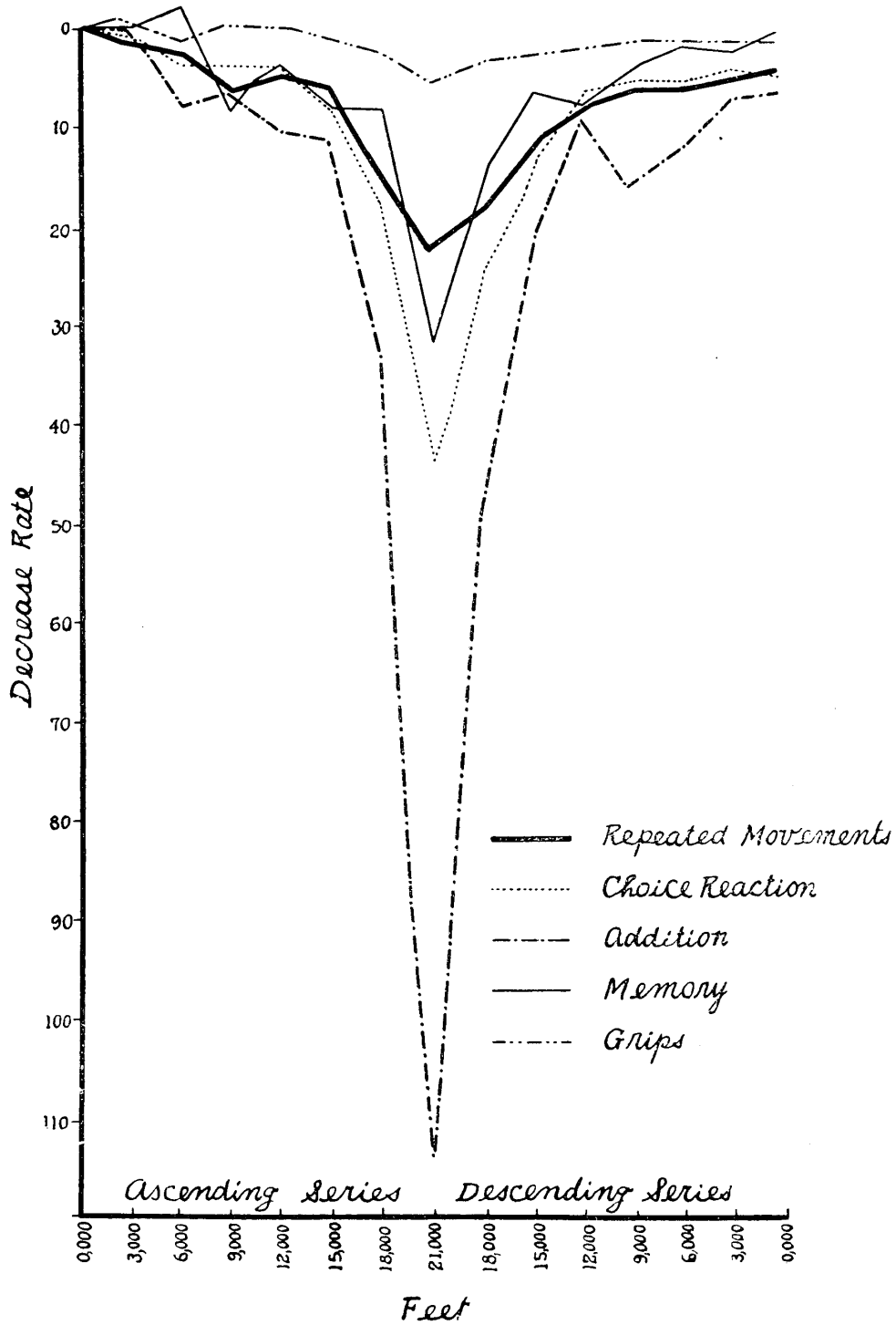


Fig. 1.

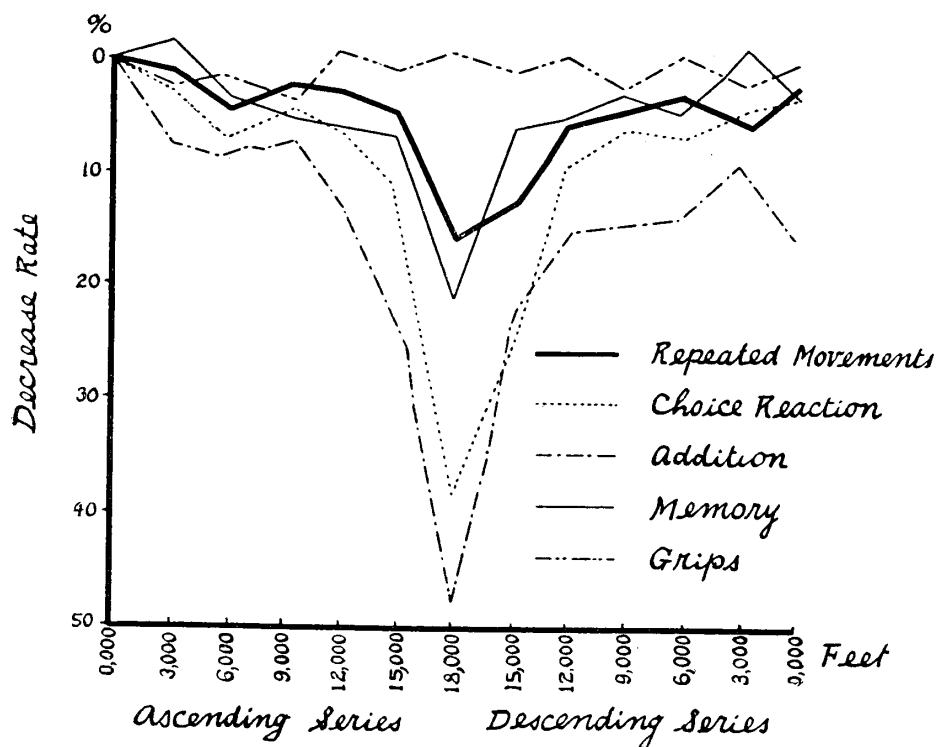


Fig. 2.

changes of barometric pressure on physical work is less than that on mental work. In support of this conclusion we have the results of the tests on strength of grips on one hand and those of addition on the other; and moreover this is not only what I could infer from the results obtained by the experiment we tried on Mount Fuji some years ago, but this is also what Professor Barcroft has foretold. Among those of mental work the results of memory work rather resemble those of strength of grips and of repeating movement than those of addition so far as the changes in the results are concerned, and the similar result is reported in the investigation by Lehmann. He made an experiment for a year with Pedersen on the influence of temperature and atmospheric pressure upon three kinds of work of grip, memory and addition, and found that the change in memory work

is more similar to that in grips than in addition (11). But it may be too hasty to conclude that the decrease in efficiency by lowering of air-pressure is more remarkable in mental work than in physical, for in this experiment the repeated movement was tested before the choice reaction if there be any influence of the low pressure, in the ascending series of experiment the influence must be larger at some later time than at the time just after when a certain low pressure is attained.

The results of the descending series of experiments in Fig. 1. may offer some facts for this doubt; i. e. from 12,000 feet downward the repeated movement has the tendency of being rather larger in its deficiency. This is because in the descending series the longer the time that passes after a certain pressure is reached, the better for the recovery it is. Therefore, there may be some room for doubt in the third conclusion, but as grips were tested last of all each time, the conclusion about it is a definite one and besides it is one to be supported by the results of the fourth and fifth experiments which are to be mentioned later on.

(4) Even in the same kind of mental work, the more complex the work, becomes the more remarkable the influence of the low pressure. To explain this fact we must compare the same kinds of work in several degrees of complexity as in repeated movement and choice reaction. Fortunately such comparison is possible in some of my experiments; i. e. in memory tests 3 subjects were tested by three cases of 8, 10 and 12 letters, while one subject by two cases of 8 and 10 letters. Now the results of each subject are arranged according to three kinds of work and we get Table XII. In this table the total marks and their average of the first day (I in the table) and of the second day (II in the table) are shown for each of the experiments, control and tank.

TABLE XII.
Comparison in the Efficiency of Memory.

Subjects	W			E			A			H		
	Control	Tank	%	Control	Tank	%	Control	Tank	%	Control	Tank	%
8 letters	I	211.0	210.0	240.0	236.0		205.0	204.0		166.0	154.0	
	II	208.0	205.0	240.0	240.0		206.0	206.0		170.0	165.0	
	av.	209.5	207.5	240.0	238.0	99.17	205.5	205.0	99.76	168.0	159.5	95.24
10 letters	I	214.0	175.0	297.0	276.0		227.0	208.0		—	—	
	II	215.0	199.0	286.0	283.0		226.0	228.0		166.0	151.0	
	av.	214.5	187.0	291.5	279.5	95.88	226.5	218.0	96.25	166.0	151.0	90.90
12 letters	I	201.0	144.0	319.0	265.0		201.0	203.0				
	II	211.0	191.0	322.0	279.0		218.0	188.0				
	av.	206.0	167.5	320.5	272.0	84.86	209.5	195.5	93.32			

The sign % in this table is the percentage of the average of the tank experiment compared with that of the control experiment. Comparison of the value of percentage given to each subject points out a certain tendency; that is to say, with the subject *W* in case of 8 letters the percentage is 99.05 showing the difference of 2 points in the average marks for these two kinds of experiments, but it is 87.18 per cent with the difference of 27.5 points in the average in case of 10 letters, and 81.31 per cent with the difference of 38.5 points in case of 12 letters, the difference being remarkably increased.

The same tendency is seen in the other cases. But separately examining each case, we find two exceptions; i. e. in II for the memory of 10 letters and in I for that of 12 letters by the subject *A*, the results of the tank experiment are rather larger than that of the control. In spite of these exceptions, the letters for memorizing are more the rate of deficiency are larger so far as the average value is concerned. Hence there is this conclusion that the more complex becomes the work, the more remarkable is the influence of the low pressure. Besides, a similar fact is observed also in the results of the reaction time tests in the fifth experiment which is to be mentioned afterwards.

(5) So far, we have observed the change of efficiency by the standard of altitude above the sea-level, but now let us observe it in reference to the partial pressure of oxygen. The change of air pressure is accompanied by that of partial pressure of oxygen. And the difference of air pressure and quantities of oxygen with the distance of 3,000 feet between in low altitude is by no means identical with the difference of those with the same distance between in high altitude. In other words, as shown in Table 33 in the appendix both air pressure and partial pressure of oxygen are relatively large in their decreasing rate in low altitude and

grow smaller as altitude increases. And within a certain limit—within the limit of my experiments, that is, up to a height of 24,000 feet in the fourth experiment—air pressure and partial pressure of oxygen show a hyperbolic change against the increasing line of altitude. So it follows that if altitude increases in arithmetic progression, both air pressure and oxygen partial pressure decrease in geometrical progression, their constant number being about 0.89 ($k=0.89$).

On the contrary, the decrease of efficiency shows quite the reverse tendency; i. e. efficiency decreases slowly at the beginning of lowering of pressure, but quickly afterwards as the pressure becomes smaller. And the turning point for its sudden decrease is about at a height of 15,000 feet (about 4,500 *mm*) and oxygen partial pressure at the height is 11.83 which corresponds to about 56 per cent of 20.96, the partial pressure of oxygen on the sea-level. By the way, the partial pressure of oxygen at the height of 18,000 feet is 10.56, corresponding to about 50 per cent of that in the ordinary barometric pressure. Therefore we can conclude that if oxygen partial pressure decreases to half the normal pressure, the decrease in efficiency is certain. This agrees with the results of the introspection and observation mentioned next.

VII. The Results of the Observation in the Tank Experiments.

It gives us much interest when the introspection of the subjects during the experiments and the observation of the experimenter are compared with the results mentioned above.

(I) The results of the introspection of the subjects are summed up as follows;

1. The most remarkable effect from the decrease of air pressure is a sense of pressure at the ear-drum. To relieve himself of

this sense the subject has to keep up deglutition movement, yet they often become unable to hear. This was what all the subjects experienced through the tank experiments.

2. When the pressure diminished to the degree of that at a height of some 12,000 feet a sense of pressure is felt all over the forehead and the ears. The less the air pressure becomes, the more remarkable the sense. Headache is experienced mostly in the course of descending—in the course of increasing pressure.

3. At a height of some 6,000 feet a sense of numbness is felt at the palm, cheeks and especially at the finger tips, the sense being increased with the decrease of the pressure and decreased with the increase of it.

4. After the height of 18,000 feet is attained breathing becomes harder.

5. Above 15,000 feet in height, a state of sea-sickness is experienced and helplessness in keeping upright position is felt. However, the mood is rather pleasant as if the subject had taken a little spirit.

These experiences depend upon the conditions and persons concerned. Some felt headache, but some not. Peripheral paralysis was experienced by all the subjects, but each had his own turning point in the barometric pressure for it according to his conditions at the time of the experiment. The subject *T* felt it at a height of 6,000 feet in the first tank experiment, but in the second he felt it at a height of 12,000 feet. Besides this feeling, a sense of projection of eye-balls or their dryness was accompanied sometimes. Generally speaking the disagreeable feeling is experienced more when the air pressure is being increased than when decreased. It seems that this feeling is to be another effect from the sense which takes place about the head.

(II) The results observed by the experimenter.

By putting together the observation notes made by the experimenter himself of the experiments and those by the assistant who observed from outside of the tank, we get the following description of the changes through which the subjects have gone during the experiments.

1. In the barometric pressure between the heights of 12,000 and 15,000 feet the complexion of the subject becomes colourless and his eye-balls are bloodshot. Between the heights of 15,000 and 18,000 feet, the skin of many of the subjects turns dark purple, the most affected parts being fingers, toes and lips, and at a height of 18,000 feet and above, the colour deepens more and more. With the increase of the air pressure, the purple colour becomes lighter and lighter; yet even below a height of 15,000 feet some shade of it can be recognized. It is at a height of some 9,000 feet and downward that the skin restores to its normal colour. Besides, with the subject, *W* and *H* some redness could be observed in their ear-laps.

2. At a height of 15,000 feet and above the subjects become very much excited. They scratch their heads, stroke their chins, and look around the room, being restless all the time. The subjects, *W* and *A*, whistled at a height of 18,000 feet and *E* sang beating time with his hands at a height of 15,000 feet and above. These changes, considered together with the results of introspection (5), show that the presence of a pleasant feeling can not be denied in the high altitude where the air pressure is low.

3. Though the subjects are very cheerful as long as they are free from the tests, they assume a very displeased attitude whenever they are asked to go through some tests at a certain barometric pressure. By facts 2 and 3 it is proved that the inhibitory power of will is weakened.

Experiment II.

The Effect of Changes in Barometric Pressures upon Muscular Strength.

I. Introductory.

In the first experiment where strength was tested 2 or 3 times by the dynamometer in a certain pressure its deficiency ratio was proved to be very small, showing the decrease to be not exceeding 4.48% of the normal strength even in the pressure at a height of 21,000 feet above the sea-level and as for the subjects who were tested up to the pressure at a height of 18,000 feet there was scarcely any change witnessed (cf. Table IX). But in the tests which examine only 2 or 3 times, the real effect of the air pressure may be covered by temporary effort. To see the actual change in efficiency in physical works, it is necessary to test in works which require relatively longer effort. For this purpose it serves us well to adopt ergograph as tried by A. Mosso.

II. Procedure of the Experiment.

I experimented with the two subjects *H* and *T* in the following procedure, using Du-Boi's ergograph. In the first place, I allowed for practice 15 days to *T* and 17 days to *H*, before I proceeded to make my experiments. The condition for both the practice and experiments was to have the forefinger of the right hand with a weight attached to it and to contract to the ticking of a metronome. With *T* the weight attached was 5 *kg* and with *H* 4 *kg* and they were to contract their fingers once in 2 seconds. They practiced at about the same hour once a day except on Sundays. The results of practice experiments are shown in Table 35 in the appendix. By the table we can see that they improved

slowly at the beginning and then abruptly, but little fluctuation after the 12th day.

The tank experiments were conducted once a day at a certain level of the pressure with the control experiment at the normal pressure made now and then. The first tank experiment was started at the pressure of 3,000 feet, the pressure being decreased by 3,000 feet each time thereafter and H was tested as high as a height of 18,000 feet and T as high as a height of 21,000 feet. This I have called the ascending series of the experiment. Next the tank experiment was started at the lowest pressure and it followed on each time when the pressure was increased by 3,000 feet. This is the descending series of the experiment. My intention was to try these 2 series twice, but due to my stay there being limited, I was compelled to content myself with two trials of the ascending, and one of the descending series. The order of experiments and their records are shown in Table 36 in appendix.

III. Results of the Experiment.

The results obtained in this experiment are shown in Table XIII. Figures in the table are reduced to the percentage of efficiency to that of the control experiment. The heavy typed figures are the average of 3 separate results. This table tells us that the rate of deficiency for both subjects as to the number of contractions is generally larger than that in the amount of the work, the exceptions being only observed with H at the pressure of 18,000 feet and with T at the pressure of 12,000 feet and 15,000 feet. As already shown, the decrease of the barometric pressure is hyperbolic to that of altitude, that is, rapidly in the beginning and then slowly, but as for efficiency, and tendency is quite contrary; i. e. it seems to decrease quite suddenly somewhere at a

TABLE XIII.

Changes of Pressures and the Efficiency in Ergograph
(% to the Efficiency in the Normal Pressure)

Subject H			Subject T		
Feet.	No. of Contractions	Amount of Work	Feet.	No. of Contraction	Amount of Work
3,000	100.70	100.72	3,000	96.42	99.65
	94.41	101.39		96.20	96.96
	97.56	98.97		96.82	98.26
	97.56	100.54		96.48	98.29
6,000	99.30	95.10	6,000	97.91	100.34
	94.41	95.25		92.41	101.20
	89.02	97.66		91.72	95.37
	94.24	96.00		94.01	98.97
9,000	93.71	95.34	9,000	95.52	99.78
	93.17	95.49		96.20	96.87
	90.24	94.84		92.99	97.01
	92.37	95.22		94.90	97.89
12,000	92.31	94.36	12,000	101.49	95.24
	94.94	92.42		96.20	92.83
	90.24	95.84		86.59	90.09
	92.50	94.21		94.76	92.72
15,000	91.28	90.02	15,000	97.91	89.25
	93.67	92.58		81.29	86.99
	88.62	94.83		90.24	89.01
	90.99	92.42		89.81	88.42
18,000	85.91	82.19	18,000	79.74	80.05
	94.94	86.62		69.68	75.91
	89.82	94.32		85.37	91.29
	90.22	87.94		78.26	82.42
			21,000	62.75	67.94
				61.94	75.33
				82.93	86.54
				69.21	76.60

pressure of 18,000 feet. *T* shows the decrease by 20% at a pressure of 18,000 feet when at a pressure of 15,000 feet it was only about 10%. If *H* had been tested at the pressure of 21,000 feet, a

sudden change must have been witnessed there. Mosso's experiment mentioned before, though made only at a height of about 15,000 feet, shows the decrease of about 20%. His subject was tested after he got used to upper atmosphere to some degree, yet the decrease was almost the same as that obtained by *T* in the pressure of 18,000 feet. Perhaps in the actual height, low temperature must have much to do with the effect.

In short, while a little decrease was shown in the dynamometre test, we observe a rather remarkable decrease by the ergograph. It may be because temporary effort is a failure on one hand, and we are physiologically subject to the effect of want of oxygen on the other when we task ourselves so hard to the point where we can contract no more. But the rate of deficiency by ergograph seems far less as compared with the choice reaction and addition in the first experiment.

TABLE XIV.

Changes of Pressures and Speed of Handwriting
(no. of letters written in 30 seconds)
(Subject *T*)

Feet	Control Exp.			Tank Exp.			%
	I	II	Av.	I	II	Av.	
3,000	62	63	62.5	64	64	64.0	102.05
6,000	63	63	63.0	59	63	61.0	97.25
9,000	60	63	61.5	60	60	60.0	95.69
12,000	60	66	63.0	58	60	59.0	94.10
15,000	60	64	62.0	54	60	57.0	90.91
18,000	60	69	64.5	44	61	52.5	83.73
21,000	60	65	62.5	37	46	41.5	66.19

Experiment III.

The Effect of Changes of Barometric Pressures upon Hand-writing.

I. Speed of Hand-writing.

Availing myself of the opportunity of entering the low pressure chamber as the experimenter in the second experiment, I made experiment in speed of writing on myself. The procedure is as follows.

Placing the lines of ruled paper on a table, at right angles to myself, I wrote from left to right the whole alphabet, beginning with as fast as possible with one letter in each space. The space between the lines was 9 mm. The time given for the writing was 30 seconds. At first about 50 letters were written in the given time, but after practice 3 times a day for one week the number was increased to about 60. When this practice ended the tank experiment was begun.

Before starting the tank experiment normal speed of writing was tested for 30 seconds in the normal pressure and then the tank experiment was conducted for 30 seconds in the desired pressure. The former was taken as a control experiment and the result of it was compared with that of the tank experiment.

The first tank experiment was conducted at the pressure of 21,000 feet, the second one at the pressure 18,000 feet and the third one at 15,000 feet and going on in the same way day after day, it ended at the pressure of 3,000 feet. This is the first series. Next, beginning at the pressure of 3,000 feet, it ended at 21,000 feet. This is the second series. The results of these experiments are shown in Table XIV.

In Table XIV, I and II signify the first and second series

respectively and Av. is the average for both, and % means the percentage of the results in the tank experiment against those in the control. Let us examine the results of the control experiment to begin with. The first series being begun at the pressure of 21,000 feet, if we compare them in order from the bottom upward we find the same number of letters (60) up to the point of 6,000 feet in every case, and then sudden increase to the number of 63. Next the second series being begun at the pressure of 3,000 feet, going on downward in order from the top, we find almost the same number for a while, but from the point of 12,000 feet downward in the table same fluctuation is observed. In a word, in the course of the tank experiments some effect of practice is disclosed. It claims our interest that even in such a simple work as writing the alphabet by hand, there is still remarkable progress in so short a time of practice. This fact explains the necessity of the control experiment in such a research, especially in the case of the second experiment mentioned above or this one which requires a number of days to get the results.

From the results of the tank experiment a remarkable difference in efficiency between the first and second series attracts our attention. To take the case at the pressure of 21,000 feet where the effect is most conspicuous, in the first series 60 letters in the control experiment compares with 37 in the tank experiment, showing the decrease of about 38% ; yet in the second series the numbers are 65 and 46 respectively, the decrease being only about 29%. Next taking the case at the point of 18,000 feet, the same is true as before ; i. e. the decrease of about 27% in the first series turns into 12% in the second owing low pressure. This may be because of getting skilful in handwriting as well as becoming accustomed to low pressure in the course of the experiments. To introspect as subject, in the earlier period of the practice some thought was

required for the letter coming next in the order of the alphabet and in such case the pronunciation movement had to accompany the effort of thought, but by the time of the tank experiment I was, apparently, free from this awkwardness. Nevertheless under the influence of low pressure I experienced the same effect as I had had in the earlier part of the practice. With this data of the introspection and that of the experiment in view, the effect of low pressure must be slight in the case of a nearly mechanized work. The same principle may well explain why the deficiency in strength is so little.

Compared with the case in the strength we observe that under these conditions the deficiency in speed of handwriting due to low pressure is fairly remarkable. If the time for work had been prolonged one minute or two, a more remarkable effect might have been witnessed. This may well be inferred from the fact that in the tank experiment remarkable fatigue was felt both in hand and arm after the work even for 30 seconds. There is another proof in support of this inference. That is from the results of handwriting, tested twice, each for 30 seconds in low pressure (at the pressure of 21,000 feet). I omitted them in the table, but to mention the number of letters here, in the first series letters numbered 27 in the second 30 seconds, while they numbered 37 in the first 30 seconds, and in the second series they numbered 35 for the second time while 46 for the first. In other words, in the first series the second one is 73% of the first, and in the second series the second is 76% of the first.

II. Quality of Handwriting.

So far we have considered only the speed of handwriting, but the comparative study of its quality appeals to us more. This is the matter which already received the attention of

the psychologists in the American Army during the Great War. They compared the letters written in the normal pressure with those in a given low pressure in order to see the resisting power to the oxygen want. For this purpose they made a scale for determining the quality of handwriting and made it the standard for estimation. (12)

I made the following experiment on my two subjects (*M* and *T*). Cutting off 2 sentences consisting of 40 words from a clearly printed advertisement of a certain university, I first made them copy them on a ruled paper with a fountain pen in the normal pressure, then at the pressure of 21,000 feet and lastly again in the normal pressure. With subject *M*, however I reduced the number of sentences to one consisting of 18 words. The results are shown in the Plate 6 and 7. Plate 6 is *T*'s achievement and Plate 7 *M*'s. In these plates (I) and (III) are the achievement in the normal pressure, the former being those before and the latter those after the tank experiment; (II) are those got at the pressure of 21,000 feet.

To compare (I) and (II) in the case of subject *T*, the former took 106 seconds and latter 97 seconds; that is (III) is quicker by 9 seconds. The same material having been copied, it must have been the effect of practice. The same fact should have held good between (II) and (I), so far as the effect of practice concerned, but the former took 288 seconds, which tells us the great effect of low pressure. Since the average for (I) and (II) is 96.5 seconds, it means that in low pressure it required about three times more time than in the normal pressure to write 40 words.

The comparison of qualities gives us far more interest than that of speed. One glance is enough to see clearly that in the achievement in the tank, each word is by far inferior, and mistakes in inserting or omitting letters are greatly increased.

I. Candidates may specialise in one of the two subjects taken, or treat each subject as of equal value. In the former case two-thirds of the total marks obtainable in the examination will be allotted to the subject of choice.

II. Candidates may specialise in one of the two subjects taken, or treat each subject as of equal value. In the former case two-thirds of the total marks obtainable in the examination will be allotted to the subject of choice.

III. Candidates may specialise in one of the two subjects taken, or treat each subject as of equal value. In the former case two-thirds of the total marks obtainable in the examination will be allotted to the subject of choice.

Plate 6. Subject 7.

- | | |
|---|----------------------|
| (I) Hand-writing in the Normal Pressure before the Tank Experiment. | Time required, 106." |
| (II) Hand-writing in the Pressure equal to that at the height of 18,000 feet. | Time required, 268." |
| (III) Hand-writing in the Normal Pressure after the Tank Experiment. | Time required, 97." |

I. Candidates may specialise in one of one of the two subjects taken, or treat or treat each subject as of equal value

II. Candidates may specialise in one of the two and one should not take more than one subject in addition to the minimum of equal value

III. Candidates may specialise in one of the two subject taken, or treat each subject as of equal value

Plate 7. Subject M.

- | | |
|---|---------------------|
| (I) Hand-writing in the Normal Pressure before the Tank Experiment. | Time required, 84" |
| (II) Hand-writing in the Pressure equal to that at the height of 18,000 feet. | Time required, 320" |
| (III) Hand-writing in the Normal Pressure after the Tank Experiment. | Time required, 76" |

Moreover, the handwriting is so defective all over that it can hardly be recognized as being written by the same person.

With subject *M* the same is true. Comparing the time spent (I) took 84 seconds and (III) 76 seconds, the latter being faster by 8 seconds. The average is 80 seconds, but in the case of (II) it is 320 seconds; that is, 4 times more time was required in low pressure than in the normal pressure. With subject *T* the repetition of the same words but with subject *M* the omissions of words were remarkable. Perhaps individual nature may have had much to do with these differences.

Referring to the record of Tissandier, Dr. Haldane stated that the indication of oxygen want can be seen in illegible handwriting and repetition of the same word. That is of no little interest to me when compared with the results of my experiment (13).

No one denies that copying work is more intellectual than simple alphabet writing. The reason why the amount of deficiency is greater in the copying work than that in the alphabet writing may be that the time for work was longer in the former case, but a far more convincing reason must be that it is more of mental work. It can be readily inferred that the main factor for the deficiency in the copying work is mental by considering the fact that after the work of about 5 minutes, not so much fatigue was experienced in both hand and arm as that after 30 seconds' alphabet writing. Of course there are the common elements of controlling the movements of fingers, hands and arms, in both simple alphabet writing and copying work. This may be readily seen from the fact that in both cases illegibility of handwriting is increased under the influence of low pressure. But it seems more rational to seek the main cause for deficiency in the copying work in the fact that mental function is more susceptible than physical to the said influence.

Experiment IV.**The Effects of Changes of Barometric Pressures upon the
Reaction Time.****I. The Serial Tank Experiment.****(A) Kinds of Reaction.**

The reaction time was measured by D'Arsonval's chronoscope. The kinds of reaction were simple reaction for auditory, tactile and visual stimuli, and choice reaction for auditory or tactile stimuli. The auditory stimulus was given by tapping of a stick held by the experimenter on a table, the tactile one by pressing the round end of the stick on tip of the middle finger of the subject's left hand whose back was held downward on the table, and the visual one by the movement of the needle of the chronoscope caused by pressing the stick on the experimenter's knee. In choice reaction, giving either the same tactile or visual stimulus as used in the simple reaction, made the subject react only for the visual stimulus and not for the tactile one. The subject was always to keep his eyes except in the case of the visual simple reaction and the reaction was effected by pressing the reaction key held in his right hand.

(B) The Practice Experiment.

Four person, *W. M. T.* and *H.* served as subjects in this experiment. Before making the tank experiment they have had practice in all kinds of reaction ten times a day. The number of practice days differs by individuals. Subject *W* practiced for 7 days, subjects *M* and *T* for 9 days, and subject *H* for 15 days. The results of the practice experiment are shown Table 37 in the appendix.

To describe the general tendency in the results thus attained, we have:

(1) In every kinds of reactions, there were more or less improvement. The most remarkable improvement was revealed in the choice reaction and the next in the tactile simple reaction. The auditory and visual reactions were less in their improvement, the least being in the latter.

(2) To compare the absolute value, the simple auditory reaction time was the shortest, except with subject *M*, the tactile came next and the visual was the longest. The visual simple reaction time proved sometimes to be longer than that of the choice reaction. Besides these each reaction showed its own characteristics, but in every method of reaction each subject showed a nearly constant speed and a very small mean variation at about the end of practice period.

(C) The Tank Experiment.

In this experiment only the tank experiment was made, and it consisted of both the ascending and descending series. Beginning at the normal pressure, it was made at the pressure of 6,000 ft. 12,000 ft. 15,000 ft. 18,000 ft. and 21,000 ft. respectively, (only subject *H* being not tested at the pressure of 21,000 ft.) This is the ascending series. Then increasing the barometric pressure by degrees, the tests were made at each point when lowered by 3,000 ft or 6,000 ft till the pressure was restored to the normal one. This is the descending series of the experiment. As to all other conditions, they were same as in the first experiment.

TABLE XV.
Changes of Pressures and Reaction Time (%)

Feed	Simple Auditory R.			Simple Tactile R.			Simple Visual R.			Choice R.					
	W	M	T	W	M	T	W	M	T	W	M	T	Av.		
0,000	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00		
6,000	101.93	104.62	102.31	102.95	108.62	107.49	106.12	101.61	101.99	103.15	102.25	100.94	101.25	105.29	102.49
12,000	104.44	107.31	108.45	106.73	104.22	107.84	107.59	102.72	105.70	103.49	103.97	106.03	114.68	114.29	111.67
15,000	107.70	111.63	109.75	109.09	109.98	115.93	109.10	111.67	106.63	108.02	107.44	112.48	115.46	117.99	115.31
18,000	117.41	117.67	112.86	115.98	121.78	119.58	111.97	117.78	110.01	110.46	114.13	118.45	127.92	120.69	122.35
21,000	124.81	123.38	123.27	123.80	132.82	122.46	133.75	129.68	126.41	112.01	124.26	205.04	143.51	143.39	123.98
18,000	112.22	126.77	121.46	120.15	118.76	115.38	128.36	120.82	122.58	111.07	121.00	113.65	125.31	123.28	120.75
15,000	112.96	118.20	118.50	116.55	114.55	121.06	118.00	117.87	115.87	110.85	116.65	114.46	129.16	121.09	121.70
12,000	103.63	112.23	119.73	111.86	104.43	104.51	115.48	108.14	102.49	103.98	114.87	107.00	106.03	116.11	117.46
6,000	101.78	109.47	113.66	108.30	100.70	102.56	103.94	105.73	102.13	104.76	110.18	105.69	101.64	102.74	115.34
0,000	100.37	104.62	106.43	103.81	101.55	100.85	103.43	101.94	100.95	102.65	104.29	102.63	100.47	102.41	109.05

TABLE XVI.

Changes of Pressures and Reaction Time (%)
Subject *H.*

Feet	Auditory	Tactile	Visual	Choice
0,000	100.00	100.00	100.00	100.00
6,000	103.41	101.34	107.41	114.79
12,000	107.80	103.38	109.28	133.44 ²
15,000	117.87	111.85	112.13	132.89 ²
18,000	119.23	116.36	122.67	142.98 ³
15,000	110.52	112.69	123.22	142.12
12,000	114.91	114.88	110.32	118.71 ²
6,000	105.53	109.66	112.35	119.91 ¹
0,000	106.43	107.55	105.10	109.97

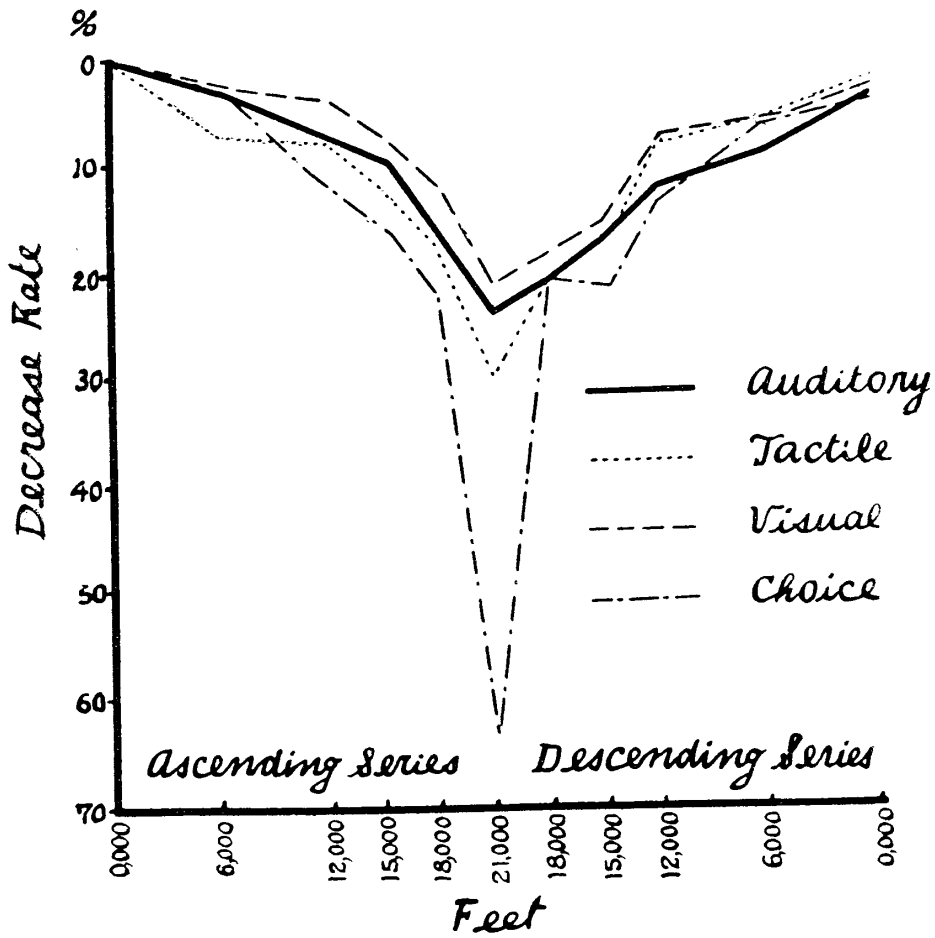


Fig. 3.

TABLE XXVII.

(Changes of Pressures and the Deviation of Reaction Time.

(Av.=Average of 3 subjects W, M, T.)

Experiments	Feet	Auditory Reaction				Tactile Reaction				Visual Reaction				Choice Reaction							
		W	M	T	II	Av.	W	M	T	II	Av.	W	M	T	II	Av.					
1	0,000	1.15	0.87	0.65	0.81	0.89	1.08	0.91	1.11	0.85	1.03	0.95	0.77	0.90	0.83	0.87	1.07	1.02	1.45	1.32	1.48
2	6,000	1.20	0.93	0.90	0.80	1.01	1.23	1.04	0.65	1.33	0.97	1.25	1.11	0.58	1.10	0.98	1.84	0.84	1.86	2.04	1.51
3	12,000	0.98	1.17	1.13	1.21	1.09	1.34	0.98	0.99	1.11	1.10	0.75	0.85	1.16	1.14	0.92	2.29	2.04	2.52	2.34	2.28
4	15,000	1.30	1.01	0.87	1.16	1.08	1.51	0.88	1.36	1.15	1.25	1.20	0.84	0.96	1.02	1.00	1.86	3.22	3.50	3.18	2.80
4	18,000	1.72	1.47	1.58	2.18	1.59	3.04	0.99	1.58	2.10	1.77	1.00	1.35	1.00	1.01	1.14	2.92	2.61	3.33	4.88	2.94
6	21,000	1.83	1.53	1.57	—	1.64	2.58	1.22	2.67	—	2.16	1.85	1.16	1.14	—	1.39	7.50	4.40	5.72	—	5.87
7	18,000	1.73	2.02	1.27	—	1.67	1.92	1.33	1.57	—	1.61	1.49	1.35	1.49	—	1.44	3.08	2.12	2.19	—	2.60
8	15,000	1.65	1.81	2.08	1.22	1.85	1.01	1.31	1.47	1.38	1.26	1.34	1.15	1.11	1.45	1.20	2.39	2.22	3.10	3.92	2.57
9	12,000	1.02	1.18	1.84	1.27	1.35	1.11	0.87	1.26	1.24	1.08	1.82	1.16	1.13	1.19	1.32	1.17	1.70	2.04	1.88	1.64
10	6,000	1.11	0.97	1.99	1.02	1.02	1.44	1.20	0.95	0.95	1.20	1.11	0.87	1.03	1.04	1.00	3.02	0.92	2.18	2.28	2.04
11	0,000	0.81	0.76	1.28	1.23	0.95	0.91	0.81	1.21	0.91	0.94	0.99	0.97	1.16	1.20	1.13	1.64	1.36	1.15	2.16	1.48

At every point of the pressure, the simple reaction time was measured five times each for auditory, tactile, and visual stimulus in the order they are given and then the choice reaction time was examined. In the choice reaction 5 stimuli each for auditory and tactile were given at random and thus choice reaction time was recorded only 5 times. After this each simple reaction time was measured 5 times in the order of visual, tactile and auditory. This order of testing has the effect of cancelling the influence caused by the different length of time exposed in a certain pressure.

The results from two experiments obtained (once a day) in this way for each subject are shown in the tables XV and XVI. In these tables, the reaction time in the first normal pressure is given by 100.0 and that in other cases by the percentage to it. The Figure 3 shows the average value of the table XV by curves. Taking individually some fluctuation is observable, but passing on the average value the general conclusion can be set forth; i. e. the facts observed in the first and third experiments are seen here again. If the facts which can be drawn from these results were itemized they are as follows:

(1) In every kind of reaction, there is slow retardation till the pressure of 15,000 feet is attained and sudden retardation there-after.

(2) In the descending series, efficiency is restored as the barometric pressure increases, yet not so much as in the case of the ascending one (cf. Fig. 3.) It must be due to some after effect which was caused while the experiment of the ascending series was conducted.

(3) Of the four kinds of reaction, the choice was the one most affected and the simple reactions show, as a rule, the least deficiency. This is but another case of the general law, mentioned

before, which explains that the more mental the work, the more remarkable will be the influence of low pressure.

(4) Of all kinds of the simple reaction, the visual reaction is the least in its retardation and the other two show nearly the same deficiency. According to the introspection of the subjects some paralysis began to be felt in their fingers from the point of 6,000 feet to 12,000 feet. Naturally in such a case the tactile sensibility must have been weakened. In the tank the earliest effect was felt about the ear-drum. The lower the barometric pressure becomes the fainter must be the sound, yet it is in so negligible a degree as to be almost unnoticed by the subjects. But sometimes its effect cannot be ignored, though imperceptible to us. Taking this fact into consideration, the weakened intensity of sound and the physical change brought on the ear-drum itself must be the factors, which cause decrease of efficiency, be that ever so little; yet the more powerful cause must be psychophysical one or same as that in the first experiment, which is responsible for deficiency of the repeating movement.

(5) Above are the observation of the results of the three subjects, but the subject *H* too shows nearly the same result as shown in the table XVI.

(6) As to the errors, a few antecedent reactions occurred occasionally in the simple reaction, but they are omitted in the tables, being very few in number. In the choice reaction, however, the number of their occurrence being relatively large, they are recorded in the tables. The number in small digits in the tables XV and XVI, are the sum total for two experiments. By them we see that they appeared already somewhere at the point of 12,000 feet and were most noticeable at the point of 21,000 feet.

(7) Now let us examine the amount of deviation shown in

TABLE XVIII.

Comparison of Reaction Time (Subj. *M.*)
Results in the Normal Pressure.

		Auditory		Tactile		Visual		Choice	
		Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.
Before Tank Exp.	First Half	14.3	0.64	13.4	0.82	17.6	0.72	15.3	0.88
	Second Half	13.8	0.86	13.6	1.12	18.0	0.80		
After Tank Exp.	First Half	14.4	0.68	13.3	0.84	18.7	0.64	15.8	1.12
	Second Half	14.4	0.70	12.0	0.82	18.4	0.88		

Results in Tank Exp. (24,000 ft.)

		Auditory	Tactile	Visual	Choice	
Tank Exp.	First Half	19.0	19.5	22.5	×	
		13.0	13.5	23.0	×	
		14.5	16.5	20.5	14.5	
		14.5	14.0	21.0	37.5	
		16.5	18.0	22.0	19.5	
		Av.=15.5 M.V.=1.80	Av.=16.3 M.V.=2.08	Av.=21.8 M.V.=0.85	21.5 ×	
	Second Half			33.0	27.0	Av.=23.4
				18.0	27.0	M.V.=5.88
				43.0	24.0	Error=3
				⋮	26.0	
				⋮	18.0	
			Av.=31.3 M.V.=8.90	Av.=24.4 M.V.=2.72	(× ...Error)	

the mean variation (Table XVII). As for the amount of M. V., it is found to be the least in the visual and auditory reactions and the next in the tactile and the most in the choice reaction. The amount of deviation in the choice reaction is not only larger than the others in their absolute value, but also the same is of their relative value to the average time of reactions. When we take the average of the relative deviation in eleven experiments in subjects *W. M.* and *T.* we have 1.29 in auditory, 1.31 in tactile, 1.12 in visual reaction and 1.58 in the choice reaction. And though with some exceptions, we can see a general tendency that the amount of deviation increases with the decrease of the pressure but decreases with the increase of the latter restoring to its normal state. This tendency is more remarkable in the descending than in the ascending series. These facts agree with the tendency for the change in the reaction time itself. Moreover, in the work where the deviation is large in the normal pressure and the amount of it is markedly so in low pressure. The percentage of the deviation at the point of 21,000 feet (the lowest pressure in this experiment) to that of the normal pressure is found to be 18.4% in auditory, 21.0% in tactile, 15.6% in visual and 40% in choice. Nearly the same tendency was observed in the result of subject *H*; i. e. in the choice reaction the deviation was greatest, and as the amount of detardation in the reaction time for three kinds of reactions are nearly the same in simple reaction, so was the case with their amount of deviation.

II. The Experiments in the Barometric Pressure equal to That at the Height of 24,000 feet Above the Sea-level.

Subject *M* volunteered to sit for the experiment in the barometric pressure corresponding to the height of 24,000 ft. He is an expert in gymnastics and his courage has always earned

our respect, to say nothing of his sturdy health. In my experiment the pressure equal to that at the height of 21,000 feet having been fixed as the maximum point of low pressure, I jumped at his kind proposal.

The experiment was carried out in the same way as in the serial tank experiment mentioned just before; i. e. the three kinds of simple reaction (auditory, tactile and visual) were tested five times each, the choice reaction, ten times, and lastly three kinds of simple reaction (visual, tactile and auditory) five times each were examined.

Table XVIII shows the results of the experiment in the normal pressure, conducted just before and after the tank experiment and those of the tank in the low pressure equal to that at the height of 24,000 feet. In the table, I, dividing the results in the normal pressure into the first and second halves, present the average reaction time (unit being one hundredth of a second) and the mean variation for each, and those in the tank experiment are shown individual reaction time, the average time and the mean variations for each kind of reaction.

To begin with the results in the normal pressure, what most attracts our attention is that there is no great difference between the average for the first and second halves in which five trials each were made. Besides this, all the results in the normal pressure after the tank experiment are larger than those before the tank except in the case of tactile reaction, but with no great difference among them.

Viewing the results of the first half in the tank experiment, we find both the average time and mean variation larger in any kind of the reaction than in the normal pressure, and especially so in the choice reaction. There are three errors, besides the retardation of time and increase of the amount of deviation. In

the results of the second half of the tank experiment, a more remarkable change is witnessed. As to visual reaction, here the average time records 24.4 and the mean variation 2.72, while they were 18.0 and 0.80 respectively in the normal pressure. This is remarkable but far less as compared with the change in the tactile reaction which follows. There are three records for this reaction. They are 33 Σ for the first, 18 Σ for the second and 43 Σ for the third time. When I was about to give stimulus on his middle finger for the fourth time after recording the last reaction time, I found the subject, who was busily engaged in the act of contracting all the fingers on his left hand showed the state of expecting the stimulus. For trial I gave him a stimulus with ordinary strength but with no response. I repeated it forcibly two or three times with the same result. Probably the subject had already fainted.

The experimenter had always been very attentive lest his subject should faint during the test and indeed anticipated and checked it with success several times thus far either by giving oxygen in time increasing the pressure in the tank, yet this time the subject was allowed to faint. Although it was hard to foresee the mishap in such an experiment where the subject shut his eyes, I was to blame for the negligence. It was, however, fortunate to see him presently recover consciousness after inhalation of oxygen for about fifteen seconds. With this mishap I could not go through a part of the second half of the tactile reaction and all the second half of the auditory reaction, but through this experiment we found a new fact that a fainting attack will come quite unexpectedly in a very short time. This may be taken as an extreme instance of the fact shown in many previous experiments that the effect of low pressure shows itself slowly in the beginning and efficiency decrease quite suddenly at

the pressure of about 15,000 or 18,000 feet.

Experiment V.

The Effects of Supplying Oxygen.

I. Introductory.

From the results of the four previous experiments, we may infer that both the physical and the mental efficiency decreases due to the lowering of the barometric pressure. But here arises a question whether the deficiency originates from the decrease of the pressure itself, or from oxygen want coincident with the decrease of the barometric pressure.

To answer this question we must, first, test the efficiency in two cases by the lowered pressure, one where oxygen is specially supplied, and the other where it is left unsupplied and then compare these results with that obtained in the normal pressure, and second, we make experiments by changing the quantity of oxygen contained there with no change in the pressure. The second experiment can be effected by Dreyer's method or by examining the work done in the closed room, a part of the air in it being replaced by nitrogen as tried by Dr. J. P. Lowson. The latter method had been experimented a little by Mr. Bourdillon, a fellow of Oxford University with some result. To my regret his illness prevented us from co-operating in this experiment which was to take place. But fortunately Dr. Lowson's report on his experiment was made public while I was making the experiments in the low pressure chamber; so after introducing some of his results, I shall proceed with the results of my own experiment.

II. Results of Lowson's Experiment.

Mr. J. P. Lowson's experiments were carried out in an air-chamber, Physiological Laboratory, Cambridge, producing the desired diminished oxygen pressure in the chamber by replacing more or less of the contained air with nitrogen. The subjects were five in number, two of them were naval medical officers, one an army medical officer, one a naval petty officer and one an army non-commissioned officer. He selected seven tests, namely, (1) Speed of movement (tapping), (2) Accuracy of movement (aiming test), (3) Speed of discrimination and reaction (sorting cards into their respective suits), (4) Formation of association (substitution test), (5) Perception of analogies, (6) Distorted sentences, (7) Same-opposite test. The amount of oxygen contained in the chamber ranged from 18.3% to 9.3%, in the normal air % of oxygen being 21).

After detailed discussion he concluded as follows:

(1) Of all the performances speed of movement (where the movement is a familiar one) is least likely to be affected.

(2) Accuracy of movement is likely to be affected as soon as the diminution of oxygen pressure approaches 50% of the normal the drop may take place rather suddenly.

(3) Discrimination time is less likely to be markedly affected (where the discriminations required are habitual), but where this does occur the drop seems to occur rather suddenly.

(4) The speed of formation of associations tends to be definitely affected when the oxygen pressure is near 50% of the normal. With regard to the three remaining tests not much can be said, except on the whole they seemed to show a resistance to oxygen deprivation.

Lowson's results are very instructive. But what is unsatisfactory in his experiments is, as the author himself has said, that

the number of observations for each test was so small and practice period so short. But they are sufficient at least to show the general tendency which is in accordance with my observation in many respects.

What interests us much along with his results is those obtained by Dr. E. Bagby with a re-breathing apparatus. Dr. Bagby found that as regards speed of movement (tapping test) the score remained fairly constant until collapse approached, while as regards aiming there was a constant but irregular decrease in steadiness during the preliminary stages. He attributes this fact to the restriction of the field of attention owing to the shortage of oxygen. (6)

III. The Effects of the Supply of Oxygen.

(A) The Procedure of the Experiments.

The experiments consist of two kinds, namely, the control and low pressure experiments. In the former the experiments were made only in the normal pressure. The latter has two parts. In one oxygen was not specially supplied but in the other it was done so purposely, the barometric pressure being decreased in both cases. The low pressure experiment was conducted in the barometric pressure equal to that at the height of 18,000 feet. The decreasing rate of the pressure was equal to that at the height of 1,000 feet per minute, and it was from the time when barometric pressure began to be decreased that oxygen was supplied at the rate of about 4 litres per minute.


I arranged those three kinds of procedures in the following order:

- (1) The control experiment (in the normal pressure).
- (2) The low pressure experiment (without oxygen).
- (3) The control experiment (in the normal pressure).

- (4) The low pressure experiment (with oxygen).
- (5) The control experiment (in the normal pressure).
- (6) The low pressure experiment (with oxygen).
- (7) The low pressure experiment (without oxygen).
- (8) The control experiment (in the normal pressure).

The tests selected for this experiment were as follows :

- (1) Speed of repeated movement (Simple card sorting).
- (2) Speed of repeated choice reaction (Complex card sorting A).
- (3) Speed of repeated choice reaction (Complex card sorting B).
- (4) Controlled association (ten digit addition).
- (5) Grips.

All but (3) complex card sorting B were carried out in the same way in the first experiment. Number (3), complex card sorting B is much alike number (2), complex card sorting A in many respects, the difference being only in 2 points: namely, the kinds of figures to be classified were seven, minimized forms  of them are presented here

and the box into which cards were sorted enlarged to 65 cm in wide. The number of cards are fifty in all, among them each of six kinds of figures contains seven, and the last eight of them.

The five tests were carried out in the following order. Speed of repeated choice reaction B, speed of repeated movement and speed of repeated choice reaction A, were tested five times each in the order mentioned, then five sums of addition were tried five times and lastly ten grips of the right hand.

The subjects for these experiments were *M.* and *T.*

(B) Results of the Experiments.

TABLE XIX.

Average Time (second) and Mean Variation of Repeated Movements and Choice Reactions (Tank experiments being made in the Pressure corresponding to that of the height of 18,000 ft.)

(Small sized numbers for the time records indicate errors)

(Subject *M.*)

	Trials	day	Repeated Move.		Choice Reaction A.		Choice Reaction B.		
			Av.	M. V.	Av.	M. V.	Av.	M. V.	
Control Experiments	I	15th	19.9	0.60	32.30 ¹	0.72	37.10	0.60	
	II	17th	20.7	0.36	32.20 ¹	0.44	36.69	0.78	
	III	19th	18.9	0.48	30.88	0.70	36.54 ³	0.76	
	IV	20th	18.1	0.24	30.96 ²	0.64	34.80	0.86	
	Average			19.40	0.42	31.59	0.63	36.28	0.73
	%				2.17		1.99		2.01
Tank Exp. without Oxygen	I	16th	20.58	0.62	34.00 ¹	0.80	39.76 ¹	0.88	
	II	21th	19.20	0.64	32.56	0.96	37.84 ³	0.98	
	Average			19.89	0.63	33.28	0.88	38.80	0.93
	%				3.17		2.64		2.40
Tank Exp. with Oxygen	I	18th	19.7	0.56	32.20 ¹	0.64	37.24 ¹	0.68	
	II	20th	19.5	0.32	32.06 ¹	0.68	36.68	0.86	
	Average			19.60	0.44	32.13	0.66	36.96	0.77
	%				2.24		2.05		2.08

TABLE XX.

Average Time (second) and Mean Variation of Repeated Movements and Choice Reactions. (18,000 feet)

(Small sized numbers by the time records indicate errors)

(Subject *T.*)

	Trials	day	Repeated Move.		Choice Reaction A.		Choice Reaction B.		
			Av.	M. V.	Av.	M. V.	Av.	M. V.	
Control Experiments	I	12th	18.78	0.50	29.26	0.60	36.52	0.95	
	II	15th	19.00	0.20	29.98 ¹	0.58	37.56 ¹	0.72	
	III	17th	18.80	0.44	29.04	0.64	36.20	0.64	
	IV	20th	18.20	0.18	28.34 ¹	0.60	35.04 ¹	0.76	
	Average			18.70	0.33	29.16	0.61	36.33	0.77
	%				1.77		2.09		2.12
Tank Exp. without Oxygen	I	13th	23.04 ²	0.64	37.50 ²	2.20	47.17	3.77	
	II	19th	20.20	0.54	32.00 ²	1.00	41.80 ¹	2.84	
	Average			21.62	0.59	34.75	1.60	44.49	2.31
	%				2.73		4.60		7.44
Tank Exp. with Oxygen	I	16th	19.60	0.40	30.40 ¹	0.48	37.60	1.32	
	II	18th	19.00	0.52	29.50	0.80	36.70 ¹	0.84	
	Average			19.30	0.46	29.95	0.64	37.15	1.08
	%				2.38		2.14		2.72

TABLE XXI.

Average time of Repeated Movement and Choice Reaction. (18,000 ft.)

Subject *M.*

Kinds of Tests	(I) Control Exp.	(II) Tank, without oxygen	(III) Tank, with oxygen	Diff. I and II	%	Diff. I and III	%	Diff. of %
Repeated Move.	19.40	19.89	19.60	0.49	2.53	0.20	1.03	1.50
Choice Reaction A.	31.59	33.28	32.13	1.69	5.35	0.54	1.71	3.64
Choice Reaction B.	36.28	38.80	36.96	2.52	6.95	0.68	1.87	5.08

Subject *T.*

Kinds of Tests	(I) Control Exp.	(II) Tank, without oxygen	(III) Tank, with oxygen	Diff. I and II	%	Diff. I and III	%	Diff. of %
Repeated Move.	18.70	21.62	19.30	2.92	15.61	0.60	3.21	12.40
Choice Reaction A.	29.16	34.75	29.95	5.59	19.17	0.79	2.71	16.46
Choice Reaction B.	36.33	44.49	37.15	8.16	22.46	0.82	2.26	20.20

(I) The results of the experiment on the speed of repeated movement and two kinds of speed of repeated choice reactions are shown in Tables XIX and XX. In the tables "average" means the average time (seconds) taken for sorting fifty cards; M. V., the average deviation for each day; "%", the percentage of the mean variation to the average. By the tables, we observe some effect of practice on both the average time and the amount of the deviation, though a few exceptions must be admitted.

First, let us compare the results of the three experiments in respect to time. Table XXI is made for this purpose. With the

subject *M* the difference between the control experiment and the low pressure experiment (without oxygen) is very small in all tests; that is in the repeated movement, it is 0.49 seconds, or no more than 2.53% of the time needed in the control experiment. In the repeated choice reaction A, it shows an increase of time by 1.69 seconds and in B of the same, by 2.52 seconds, the former requiring 5.35% and the latter, 6.95% more time than that needed for the control experiment.

Next, in the low pressure experiment (with oxygen) there are the increases in time, 0.20 seconds for speed of repeated movement, 0.54 seconds for repeated choice reaction A, 0.68 seconds for repeated choice reaction B, and these rendered into percentages to the results of the control experiment will be 1.03, 1.71, and 1.87% respectively. Thus we can conclude that these are the deficiency rate owing chiefly to the barometric pressure itself.

Going on further seeking the difference between the results of the two kinds of the low pressure experiments (without oxygen and with oxygen), we find it to be 1.50 in speed of repeated movement, 3.64 in speed of repeated choice reaction A, and 5.08 in B of the same as shown in the right end of Table XXI.

Now, let us turn to the results by subject *T* which are presented in Tables XX and XXI. This subject is more affected in the low pressure than subject *M*. Namely, he showed a deficiency as compared with control experiment, by 2.92 (15.61%) in speed of repeated movement, by 5.59 (19.17%) in speed of choice reaction A, and by 8.16 (22.46%) in B of the same. In the low pressure experiment (with oxygen) he showed a decrease of 0.60 (3.21%), 0.79 (2.71%) and 0.82 (2.26%) for the three tests respectively, as compared with the control experiment. The difference between the two kinds of the low pressure experiments are 12.40,

16.46, and 20.20 in percentage. The supplying or not supplying of oxygen must be the cause of these differences.

In the results of the two subjects, we notice some differences between the control experiment and the low pressure experiment with oxygen supply. It is yet to be seen whether (1) the low pressure itself or (2) some distraction of attention owing to the breeze in the mouth caused by the supply of oxygen or (3) the co-operation of these two, is responsible for it. From the facts that in the low pressure experiment (with oxygen), a strange sensation about the ears and the congestion in eyeballs were experienced, probably the third may be the cause for the said differences. At any rate, it is plain that nearly the same efficiency for work as in the normal pressure can be expected even in the low pressure, if oxygen were specially supplied, yet how much oxygen will be the sufficient supply to have such a result is yet kept in store for further study.

Now, we go on with the comparison of the decrease rate for the three kinds of work in the low pressure experiment (without oxygen). In mentioning the results of the first experiment, I stated that the low pressure affected the intellectual work more than the physical and in the intellectual work, it affected complex work more than simple work, but then I reserved room for some doubt about the conclusion, because in the comparison of the repeated movement with the repeated choice reaction, some effect of the order in which they were tested, was possible, for the former was always tested before the latter. But in the present experiments, as they were repeated five times in the order of repeated choice reaction B, repeated movement and repeated choice reaction A, after the desired diminished pressure was attained, the least affected must have been the repeated choice reaction B, then repeated movement and the most affected the

repeated choice reaction A, if the effect from the order of testing had to be admitted. If the decrease rate of the repeated choice reaction B be large even under these conditions, my presumption will be defended, and in fact, the experiments support this conclusion with their results. By comparing the difference between (I) and (II) and the values in the percentage columns of the table XXI, I find the least effect on the repeated movement and the most on the repeated choice reaction B, either in regard to the absolute retardation of time or their percentage. There is a great difference in the affected degree by individuals. Subject *T* is much more affected than subject *M*. But they show quite the same tendency in the way of being affected.

The above is an observation about the speed of work. Now about the regularity of it. The comparison of the amount of the mean variation will do for the purpose. According to the tables XIX and XX, the results of the control experiment shows the least and the low pressure experiment without oxygen, the most of absolute amount of M. V. The comparison of the percentage of M. V. in relation to the average time is shown in the last line of the tables XIX and XX. Here we find that the relative deviation is the least in the control experiment and the most in the low pressure experiment without oxygen. Therefore we may conclude that the fluctuation of the work shown in absolute and relative amount of deviation increases under the influence of oxygen want. Lastly we take up the number of errors as another index of the quality of work. They are recorded in small sized numbers at the side of the time records in Tables XIX and XX. With *M*, there is no error in repeated movement, in every kind of experiments, but some errors occurred in the other two tests. In regard to the repeated choice reaction *A*, the number recorded is on an average 1, in both the control experiment and low

TABLE XXII.

Total Time required for each Five Problems of Addition and Mean Variation (Small sized numbers by those of time records indicate mistakes).

Subject *M.*

Trials	(I) Control Exp.		(II) Tank Exp. without oxygen		(III) Tank Exp. with oxygen	
	Time	M. V.	Time	M. V.	Time	M. V.
1	49.30 ²	4.28	56.44 ²	4.76	51.70 ³	2.92
2	47.96	1.96	50.20 ³	3.24	50.10 ¹	3.92
3	51.80 ²	2.64	—	—	—	—
4	49.40	3.72	—	—	—	—
Average	49.62	3.15	53.32	4.00	50.90	3.42
Average of mistakes for one trial	1.00		2.50		2.00	

Subject *T.*

Trials	(I) Control Exp.		(II) Tank Exp. without oxygen		(III) Tank Exp. with oxygen	
	Time	M. V.	Time	M. V.	Time	M. V.
1	43.30	1.84	70.2 ⁶	6.44	51.20 ⁴	5.88
2	45.20 ³	5.84	50.5 ⁴	4.60	45.00 ³	1.40
3	43.20	2.72	—	—	—	—
4	43.20 ²	1.92	—	—	—	—
Average	43.73	3.08	60.35	5.52	48.10	3.64
Average of mistakes for one trial	1.25		5.00		3.50	

TABLE XXIII.

Average Time (seconds) required for each Five Problems of Addition.

Subject	(I) Control Experiment.	(II) Tank Exp. without oxygen.	(III) Tank Exp. with oxygen.	Diff. between I and II	%	Diff. between I and III	%
M.	49.62	53.32	50.90	3.70	7.46	1.28	2.58
T	43.73	60.35	48.10	16.62	38.01	4.37	9.99

TABLE XXIV.

Changes in Time required for each Problems of Addition (%)

Subject *M.*

	1st Problem	2nd Problem	3rd Problem	4th Problem	5th Problem
Control Exp.	100.00	102.06	98.97	109.28	108.25
Tank, without oxygen	100.00	100.99	106.93	107.92	113.86
Tank, with oxygen	100.00	106.32	111.58	108.42	111.53

Subject *T.*

	1st Problem	2nd Problem	3rd Problem	4th Problem	5th Problem
Control Exp.	100.00	109.59	112.66	116.46	119.00
Tank, without oxygen	100.00	134.04	126.60	134.04	139.46
Tank, with oxygen	100.00	111.24	106.74	104.74	123.59

TABLE XXV.

Comparison of the Average Time required for the First Two Problems and that of the Last Three Problems.

Subjects	Kinds of Exp.	Average time required for the first 2 Problems	Average time required for the last 3 Problems	%
M	Control	9.80	10.23	104.38
	Tank, without oxygen	10.15	11.07	109.06
	Tank, with oxygen	9.80	10.53	107.45
T	Control	8.20	9.17	111.83
	Tank, without oxygen	11.00	12.53	113.91
	Tank, with oxygen	9.35	9.93	106.20

pressure experiments with oxygen, while it is on an average 0.5 in low pressure experiment without oxygen, but in regard to the repeated choice reaction B, it is 0.75 in the control experiment, 2 in the low pressure experiment without oxygen and 0.5 in the low pressure experiment with oxygen. With subject *T* it is more remarkable; i. e. in regard to repeated movement the number recorded is none in the control experiment and low pressure experiment with oxygen, on an average 1 in low pressure without oxygen, while in case of repeated choice reaction A it is on an average 0.5 both in the control experiment, and low pressure experiment without oxygen. In regard to repeated choice reaction B the number of errors are the same in the test just mentioned. These results with some exception proves that the effect of oxygen specially supplied will be the decrease in the number of errors.

(2) In the addition work, five problems to be answered five times in one sitting. The average time for five problems,

the mean variation and mistakes made are shown in the table XXII. The table XXIII is the comparison of the average time. This table shows the same tendency already mentioned in such as repeated movement; i. e. with subject *M* the retardation of time is not so remarkable even in low pressure experiment without oxygen but with *T* the contrary is the case. In the low pressure experiment with oxygen, the effect of oxygen supply is conspicuous to some extent: that is, the results of both subjects approach those of the control experiment, yet some difference between them must be recognized at the same time. This difference may be attributed to the effect of the low pressure itself and the fluctuation of attention owing to the supplying of oxygen.

The amount of the average deviation shows almost the same tendency as that of the retardation of time, i. e. with subject *M*, it records 4.00 (127%) in the experiment II, and 3.42 (108.57%) in the experiment III against 3.15 in the experiment I; and with subject *T* they are 5.52 (179.16%) in the experiment II, and 3.64 (118.18%) in the experiment III, against 3.08 in the experiment I.

Now, we look at the change in the course of work curves. In this experiment, the time required for each problem being recorded, the work curves can be observed from two sides: The first is to observe the time required for each problem one by one successively and the second to observe the change in five separate groups in each of which five problem are combined. The result obtained by the former is shown in the table XXIV. This table shows the percentage of the average time required for each problem of every series of experiments in relation to the average time required for the first one which is recorded as 100.

The course of each work curve being very irregular, apparently no definite conclusion can be made, except in regard to

the result of the control experiment obtained by subject *T*. But it is obvious that in the low pressure, the work curves tend to be greatly irregular. This is a fact already made clear in the comparison of the mean variations.

The table XXV shows the percentage of the average time required for the problems from the third to fifth against that for the first and the second problems.

As clearly shown in the table, the average time for the first two problems in the low pressure experiment without oxygen being large, very great difference in their value of percentages can not be noticed between the results of the several experiments, yet little as the differences are, they are the greatest in the low pressure experiments without oxygen. Accordingly it can be said that the latter part of the work curves in addition under the low pressure experiment without oxygen show the marked decrease of efficiency.

TABLE XXVI.

The Deviation (M. V.) in Addition.

Subject.	Kinds of Exp.	Av. of M.V.	M.V. in first two	M.V. in last three	Diff.
M	Control	1.23	1.07	1.33	0.26
	Tank (without oxygen)	1.18	0.94	1.35	0.41
	Tank (with oxygen)	1.11	1.16	1.07	-0.09
T	Control	1.11	1.01	1.17	0.16
	Tank (without oxygen)	1.85	1.56	2.04	0.48
	Tank (with oxygen)	1.39	1.16	1.62	0.46

TABLE XXVII.
Changes of Work Curves in Addition.

Subjects	Kinds of Experiments	1	2	3	4	5
M	Control	48.1	44.9	49.3	54.1	51.6
	Tank (without oxygen)	50.5	50.1	55.0	57.3	53.6
	Tank (with oxygen)	46.5	55.0	51.3	53.3	48.5
T	Control	41.9	41.0	45.3	42.9	46.4
	Tank (without oxygen)	51.0	55.8	63.8	66.8	61.5
	Tank (with oxygen)	51.8	50.8	47.8	43.3	47.5

TABLE XXVIII.
Changes of Work Curves in Addition.

Subjects	Kinds of Experiments	Diff. between 1 and 5	%	Diff. between average of first two and last three	%
M	Control	3.5	7.28	5.2	11.13
	Tank (without oxygen)	3.5	6.18	5.0	9.94
	Tank (without oxygen)	2.0	4.30	0.2	0.39
T	Control	4.5	10.75	3.4	8.19
	Tank (without oxygen)	10.5	20.59	9.1	16.85
	Tank (with oxygen)	-4.3	-7.77	-5.1	-9.94

Next, let us look at the change in the amount of deviation along with the progress of the work. The average of mean

variation in each five problems for the first and second problems as one group and for those from the third to the fifth as the other group are separately shown in Table XXVI. When compared in their low pressure experiments, we observe that both subjects show a larger average of deviation and larger retardation rate in the latter part of the work when oxygen is not supplied, though we must admit a special case with subject *M* whose total average of the mean variation is the largest in the control experiment. It is a remarkable fact indeed to see such change in the speed of work and the average deviation in so short a duration of work as less than one minute.

Next, let us observe the change of work curves from the second side. Table XXVII shows the average time for each group which consists of five problems. In the table "1, 2,...5" means the order of the groups. Here again we see the irregularity in the course of the work curve owing to the insufficient number of experiments. Table XXVIII shows the difference between the first and fifth groups and also the difference between the first two groups and the last three groups. By the table we see that the difference in the results of the three kinds of experiments is not so great as seen in the comparison of the absolute time, yet viewed from the change of the course of work curves, the decrease rate is the least in the low pressure experiment with oxygen, and with subject *T* the time required for the work is shortened gradually. The control experiment being compared with the low pressure experiment without oxygen, we see that with subject *M* the decrease rate is rather less in the latter and with subject *T* vice versa. This may be a natural result of the fact that subject *M* has been affected little both in the comparison of the absolute time in the case of the low pressure experiment with no supply of oxygen.

Lastly, let us examine the number of mistakes. If we calculate the percentages to the number of mistakes in the control experiment by Table XXII, with subject *M* we have 250% in the low pressure experiment without oxygen and 200% in the low pressure experiment with oxygen, and with subject *T* 400%, and 280% in the respective experiments. Thus we notice more clearly the effect of low pressure on the quality of addition than on its speed. And the differences of the percentages of mistakes in the two kinds of low pressure experiments 50 with subject *M* and 120 with subject *T*. These may be taken as the quality differences of efficiency which arises from supplying or not supplying oxygen.

(3) Now, on the effect on strength. Grips were tested ten times successively in each experiment and the results are shown in Table XXIX. The table shows the average grip (unit being kg.) for all kinds of experiments, and their respective percentages for the rest against its first grip in every series of experiments. The average in the right shows the average of averages, and *M.V.* the average of the mean variation for each day.

Let us first compare the results of three kinds of experiments in reference to their total average value. With subject *M* almost no difference can be seen: only in the control experiment, it is 0.40 kg (0.30%) more than in the low pressure without oxygen and 0.60 kg (0.46%) more than in the low pressure experiment with oxygen. With subject *T*, the results in both the control experiment and the low pressure experiment with oxygen are quite equal, showing the difference of only 0.08 kg, yet in the low pressure experiment without oxygen we find the decrease of 9.0 kg (7.34%) compared with the results of the control experiment. In the results of various experiments already mentioned, subject *M* always has had the small decrease rate and here he

TABLE XXIX.

Changes in Strength of Grips (unit, kg.)

Subject *M.*

	No.	1	2	3	4	5	6	7	8	9	10	Av.	M.V.
Control	Av.	148.3	139.3	131.8	130.8	131.5	128.5	130.0	124.8	125.5	125.6	131.3	5.19
	%	100.00	91.37	88.87	88.20	88.67	86.65	87.44	84.15	84.56	84.69		
Tank, without Oxygen	Av.	146.5	138.5	135.0	131.0	130.0	126.0	127.0	126.0	125.5	123.5	130.9	5.72
	%	100.00	94.54	92.15	89.42	89.74	86.69	87.37	86.69	86.35	84.98		
Tank, with Oxygen	Av.	142.5	135.0	133.5	131.0	131.0	130.0	128.5	126.0	125.6	124.5	130.7	4.19
	%	100.00	94.78	93.68	91.93	91.93	91.24	90.18	88.42	87.72	87.36		

Subject *T.*

	No.	1	2	3	4	5	6	7	8	9	10	Av.	M.V.
Control	Av.	132.8	129.3	125.3	124.0	124.0	121.5	118.3	118.0	118.5	117.5	122.6	4.46
	%	100.00	96.61	94.34	93.37	93.37	91.49	89.08	88.86	89.23	88.49		
Tank, without Oxygen	Av.	126.5	126.0	119.0	117.0	109.0	113.5	111.0	106.5	103.5	103.5	113.6	7.30
	%	100.00	99.60	94.07	92.49	86.09	89.72	87.75	84.19	81.82	81.82		
Tank, with Oxygen	Av.	134.0	130.0	130.0	128.5	123.5	118.5	115.0	119.0	119.0	113.5	122.0	6.81
	%	100.00	97.01	97.01	95.90	92.90	88.43	85.82	88.81	88.81	84.70		

TABLE XXX.
Changes in Strength of Grips.

Subject.	Kinds of Exp.	(I) Av. of first 5 grips	(II) Av. of last 5 grips	% of II to I.
M	Control	135.8	126.9	93.45
	Tank, without oxygen	136.2	125.6	92.22
	Tank, with oxygen	134.6	126.8	94.21
T	Control	127.1	118.8	94.81
	Tank, without oxygen	119.5	107.6	90.04
	Tank, with oxygen	129.2	117.0	90.56

none of it, but with subject *T* we observe it to some extent.

Now, we proceed to the comparison of the mean variations. For both subjects we find their maximum in the low pressure experiment (without oxygen). Subject *M* has his minimum in the low pressure experiment (with oxygen) and subject *T* in the control one. A similar fact was already observed in the case of addition. With all this inconsistency we may conclude that though oxygen want gives little effect on the absolute amount of grips, yet it shows itself on the deviation as shown in the amount of the mean variations.

Next, we take up the work curve. The comparison of % columns in Table XXIX shows little difference in the curves for subject *M*, though the decrease rate seems to be the least in the case of the low pressure experiment with oxygen. With subject *T* we see the least decrease rate in the curve of the control experiment. These facts can be shown more distinctly when we.

compare the former and latter halves of the work-curves. Just comparing the average of the first five grips with that of the last five and obtaining their percentages, we have Table XXX. Then it will be found that with subject *M* the decrease rate for the latter half is rather small in the case of the low pressure experiment with oxygen. With subject *T* the results of the control experiment show the least decrease rate, as viewed from the general course of the work curves in their percentages, and the other two cases show nearly the same effect.

The above are what I have obtained by my experiments, but it is regrettable that there were many cases in which definite conclusions could not be reached from want the number of subjects, and it was especially so because one of the subjects did not show much deficiency under the conditions of these experiments. If I go a step farther and make experiments on the same subjects with the same method after Lawson I shall be able to determine analytically the effects from the low pressure itself and from want of oxygen but here I shall be content with the general survey.

Finally, let us append the investigation by M. Flack and C. B. Head, which tells us of the effectiveness of the supply of oxygen even in the flight at a relatively low altitude. They examined two cases, one with special supply of oxygen and the other without, just before and after flight which lasted from 20 to 60 minutes or longer, in the air at heights from 3,000 to 15,000 feet and found the former case with less pulsation, lower blood pressure, longer breath-holding and better achievement in McDougall's dotting machine (14).

The Conclusion.

The results of my five experiments and those got by others can be summarized as follows.

(I) According to the results of the low pressure experiments and of those with and without special supply of oxygen, the deficiency of mental and physical work in the low pressure is chiefly due to the oxygen want consequent on the low pressure. Therefore if oxygen be supplied by some means a great effect may not be felt on efficiency even in a high altitude with a fairly low pressure.

(II) The effects on both physical and mental efficiency caused by oxygen want differ with kinds of work, individuals, and physical conditions even in the same person. The last can well be proved by the fact that the same person does not always faint in the same low pressure.

(III) As for kinds of work, effect is more marked in the mental work than in the physical one, and so it is, in the more complex mental work.

The fact that there is less marked effect in a habitual work another expression of the same law.

(IV) In any kind of work, a certain degree of low pressure when efficiency shows a sudden drop—a turning point for deficiency—can be observed. A fainting attack which comes instantly can be taken as an instance of this fact.

(V) The turning point for deficiency is understood to be below about 428mm of pressure, or at the height over 15,000 feet above the sea-level. The partial oxygen pressure there, corresponds to about 50% of that on the sea-level.

(VI) Deficiency of work is more noticeable in the quality of work viewed from two sides, deviation of work shown in mean

variation, and mistakes, than in the amount or speed of work.

(VII) The chief phenomena experienced by subjects in the low pressure experiments are various changes in peripheral organs, a sense of seasickness which gives a feeling of unsteadiness.

(VIII) The objective symptoms which are observed by experimenters are change in colour on the skin and excited attitude.

List of References.

- (1) A. Mosso, *Life of Man on the High Alps*, (Translated from the second edition of the Italian by E. L. Kiesow) 1898.
- (2) E. Whymper, *Travels amongst the Great Andes of the Equator*, 1892.
- (3) J. Barcroft, and others, *Report of the Monte Rosa Expedition of 1911*, published in 1914.
- (4) C. G. Douglas, J. S. Haldane, Y. Henderson and E. C. Schneider, *Physiological Observations made on Pike's Peak, Colorado, with special reference to Adaptation to Low Barometric Pressures*, 1912.
- (5) H. M. Johnson and F. C. Paschal, *Psychological Effects of Deprivation of Oxygen*,—*Psycho-Biology*, Vol. II. 1920.
- (6) E. Bagby, *the Psychological Effects of Oxygen Deprivation*,—*J. of Comparative Psychology*, Vol. I. 1921.
- (7) C. D. H. Corbett and H. C. Bazett, *A Study of the Reaction of Pilots and Observers to Diminished Oxygen Pressure*, (Medical problems of Flying) 1920.
- (8) G. Dreyer, *A Simple Procedure of Testing the Effect of*

- “Oxygen Want” on Flying Man,-----Medical Problems of Flying, 1920.
- (9) J. P. Lowson, The Effect of Deprivation of Oxygen upon Mental Processes-----British J. of Psychology, Vol. XIII. Part 4. 1923.
- (10) Psychological Investigations with Low Oxygen Tension, ----- Air Service Medical, War Department, U. S. A., 1919.
- (11) Lehmann und Pedersen, Das Wetter und unsere Arbeit, -----Arch. f. d. Gesamte Psy. X. 1907.
- (12) Air Service Medical, pp. 312—314 1919.
- (13) J. S. Haldane, Respiration, p. 376, 1922.
- (14) M. Flack and C. B. Head, Report on the Value of Oxygen to aviate relatively Low Altitudes-----the Medical Problems of Flying, 1920.

Appendix.

Herewith I present all the raw materials that I obtained in my experiments, believing that they may be of some use to those who wish to refer to them in their own investigations.

TABLE I.

Results of Practice Experiment in Repeated Movements,
Average time (seconds) required for sorting up 50 cards
and their Mean Variation.

Day	W		E		M		T		A		H	
	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.
1	19.9	.92	32.3	1.08	28.7	.72	23.4	.88	23.0	.40	20.4	.68
2	18.9	.60	29.6	1.48	29.1	.92	21.2	.52	23.3	.52	19.6	.56
3	19.0	.20	27.7	2.24	26.9	.44	20.4	.44	22.8	.94	18.4	.32
4	19.1	.48	26.6	0.72	21.2	.80	20.1	.10	23.0	.66	19.2	.60
5	18.8	.76	25.1	0.76	24.8	.50	20.4	.48	23.2	.36	20.6	.62
6	17.8	.60	25.5	0.40	22.2	.26	19.9	.52	23.8	.24	20.0	.80
7	18.1	.36	24.6	0.38	20.9	.58	19.6	.32	23.4	.56	20.5	.40
8	18.0	.08	—	—	20.4	.28	20.0	.40	22.0	.40	20.4	.68
9	18.2	.28	—	—	—	—	19.3	.24	—	—	20.8	.64
10	—	—	—	—	—	—	18.6	.20	—	—	19.5	.20
Difference, first and last day	1.7		8.3		8.3		4.8		1.0		0.9	
Improvement rate	8.54%		23.84%		28.92%		20.51%		4.38%		4.41%	

TABLE 2.

Result of Practice Experiment in Repeated Choice Reaction
Average time (seconds) required for sorting up 50 cards
and their Mean Variation.

Day	W		E		M		T		A		H	
	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.
1	42.2	3.44	47.1 ²	3.12	43.0	1.68	40.8	1.76	47.4	4.88	39.5 ²	4.40
2	33.8	1.04	39.7 ¹	2.92	40.7 ²	1.00	37.1 ²	1.84	36.1	1.92	33.3 ¹	0.96
3	29.8 ¹	1.44	32.9	0.92	38.3	0.52	36.7	1.88	34.9	0.92	30.5	0.20
4	29.9	0.94	31.2 ¹	0.96	37.3 ¹	1.08	35.0	0.20	33.2	0.80	30.8	0.44
5	27.8	1.40	31.4 ²	1.02	36.5 ¹	0.76	32.9 ¹	0.40	32.7	1.24	31.4 ¹	0.72
6	28.9	1.54	30.0 ¹	0.40	33.8	0.52	33.2 ²	1.04	32.3	1.44	30.1	0.52
7	28.1	0.68	28.6	0.68	32.5	0.56	32.4	0.76	34.1 ¹	1.52	29.7	0.36
8	27.9	1.28	—	—	32.6	0.56	31.7	0.44	32.9	0.96	29.6	0.76
9	27.4	1.12	—	—	—	—	31.7	0.24	—	—	28.8	0.96
10	—	—	—	—	—	—	29.7 ¹	0.44	—	—	30.0	0.84
Difference, 1st and last day	14.8		18.5		10.4		11.1		14.5		9.5	
Improvement rate	35.07%		39.28%		24.19%		27.21%		30.38%		24.95%	

(Small sized digits by the number of average time are total number of mistakes on the respective day.)

TABLE 3.

Results of Practice Experiment in Addition. Average time (seconds) required for 5 Problems and their Mean Variation.

Day	W		E		M		T		A		H	
	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.
1	36.3 ²	2.57	56.3 ⁴	6.25	90.1 ⁹	8.05	68.2 ⁴	3.83	57.4 ⁷	3.58	100.3 ²⁹	8.75
2	33.7 ¹	2.43	58.0 ³	5.33	76.4 ³	5.58	66.1 ³	7.63	46.5 ⁵	4.17	90.1 ⁸	7.83
3	31.2 ¹³	1.33	50.7 ¹	3.03	75.3 ³	6.98	65.3 ²	8.85	49.5 ³	6.09	86.8 ¹⁶	9.57
4	32.6 ⁸	2.42	49.6 ¹	2.45	75.0 ²	3.33	60.2 ¹	5.67	52.4 ²	4.95	74.7 ¹⁰	7.00
5	31.8 ⁷	0.75	52.2	5.83	72.0	5.22	59.3 ⁷	8.60	48.8 ³	5.57	84.5 ¹⁵	8.00
6	29.3 ⁸	1.96	48.2 ²	3.90	63.8 ²	2.93	55.2 ²	3.57	46.3 ³	3.80	89.3 ⁶	6.18
7	31.8 ³	1.75	43.8 ³	3.25	64.7 ³	2.57	53.7	6.32	51.1 ²	7.75	72.3 ⁴	4.43
8	29.7 ⁸	1.17	—	—	67.4 ²	4.58	53.8 ²	2.88	49.0 ³	3.00	65.9 ¹⁰	9.92
9	30.0 ⁶	3.53	—	—	—	—	51.5 ¹	4.67	—	—	64.6 ⁷	1.75
10	—	—	—	—	—	—	52.7	2.00	—	—	70.5 ⁷	5.17
Difference, first and last day	1.2		12.5		22.7		15.5		8.4		38.8	
Improvement rate	17.13%		22.20%		25.19%		22.73%		14.06%		35.5%	

TABLE 4.

Results of Practice Experiment in Grips. Average value (Kg.) of five trials and their Mean Variation.

Day	W		E		M		T		A		II	
	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.
1	91.0	11.60	108.0	9.60	120.9	7.47	115.0	4.00	83.5	4.80	83.0	4.40
2	111.5	5.20	111.0	5.20	104.4	7.88	104.0	1.60	97.0	10.40	86.0	3.60
3	116.0	5.20	116.0	7.20	108.7	7.24	119.0	3.20	95.4	9.68	85.5	1.80
4	118.0	5.60	122.0	2.80	104.2	6.20	118.0	3.60	83.8	2.04	87.0	4.40
5	122.2	3.36	117.0	4.80	112.6	6.70	123.0	2.40	87.9	5.60	87.8	2.88
6	124.0	3.60	117.2	1.84	123.9	2.12	120.0	6.00	97.4	6.08	86.0	4.20
7	127.0	3.20	123.4	1.92	124.3	2.24	121.0	3.20	83.6	9.12	81.0	5.60
8	127.6	4.32	—	—	124.2	3.04	122.0	4.40	85.0	5.40	80.5	2.60
9	126.2	3.44	—	—	—	—	122.1	3.48	—	—	87.0	3.60
10	—	—	—	—	—	—	127.5	2.00	—	—	85.0	4.40
Difference, first and last day	35.2		15.4		3.3		12.5		1.5		2.0	
Improvement rate	38.68%		14.26%		2.73%		10.87%		1.80%		2.41%	

TABLE 5.

Changes of Pressures and Repeated Movements. (Subject E.)

Tests	Control Exp.				Tank Exp.				Diff. of %	
	I	II	Av.	%	Feet	I	II	Av.		%
1	21.2	22.5	21.9	100.00	0,000	22.0	21.5	22.0	100.00	0
2	22.5	21.5	22.0	100.46	3,000	23.8	21.8	22.8	103.64	+ 3.18
3	22.5	21.0	21.8	99.54	6,000	23.0	22.0	22.5	102.27	+ 2.73
4	22.0	21.0	21.0	95.89	9,000	24.0	21.0	22.5	102.27	+ 6.38
5	21.0	21.0	21.0	95.89	12,000	23.0	22.0	22.5	102.27	+ 6.38
6	21.0	22.0	21.5	98.17	15,000	23.5	21.8	22.7	103.18	+ 5.01
7	21.8	21.0	21.4	97.72	18,000	25.0	22.0	23.5	106.82	+ 9.10
8	21.0	21.5	21.3	97.26	21,000	28.0	*24.9	26.5	120.45	+ 23.19
9	22.5	22.0	22.3	101.83	18,000	30.0	23.0	26.5	120.45	+ 18.62
10	21.5	20.5	21.0	95.89	15,000	25.0	22.0	23.5	106.82	+ 10.93
11	21.7	20.0	20.9	95.43	12,000	25.0	21.0	23.0	104.55	+ 9.12
12	22.0	21.2	21.6	98.63	9,000	25.0	21.0	23.0	104.55	+ 5.92
13	21.0	20.0	20.5	93.61	6,000	23.0	21.0	22.0	100.00	+ 6.39
14	21.2	20.0	20.6	94.66	3,000	23.0	21.0	22.0	100.00	+ 5.94
15	20.0	20.5	20.3	92.69	0,000	23.0	20.0	21.5	97.73	+ 5.04

* Assumed Number.

TABLE 6.

Changes of Pressures and Repeated Movements. (Subject *M*.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	20.0	19.5	19.8	100.00	0,000	19.8	19.5	19.7	100.00	0
2	20.5	20.0	20.3	102.53	3,000	20.0	19.0	19.5	98.98	- 3.55
3	20.0	18.8	19.4	97.98	6,000	19.8	19.0	19.4	98.48	+ 0.50
4	19.8	19.2	19.5	88.48	9,000	21.0	19.2	20.1	102.03	+ 3.55
5	20.0	19.2	19.6	98.99	12,000	20.5	19.8	20.2	102.54	+ 5.07
6	19.5	19.0	19.3	97.47	15,000	20.8	20.0	20.4	103.55	+ 6.08
7	19.0	20.0	19.5	98.48	18,000	21.0	23.0	22.0	111.68	+ 13.20
8	19.8	19.2	19.5	98.48	21,000	21.2	23.8	22.5	114.21	+ 15.73
9	19.0	19.0	19.0	95.96	18,000	21.0	22.0	21.5	109.14	+ 13.18
10	20.0	19.0	19.5	98.48	15,000	20.5	22.0	21.3	108.12	+ 9.64
11	19.0	18.2	18.6	93.94	12,000	20.0	20.5	20.3	103.05	+ 9.11
12	20.0	17.5	18.8	94.95	9,000	20.0	20.5	20.3	103.05	+ 8.10
13	18.5	18.5	18.5	93.43	6,000	20.0	19.0	19.5	98.98	+ 5.55
14	19.0	18.8	18.9	95.45	3,000	20.0	19.8	19.9	101.02	+ 5.57
15	18.5	18.5	18.5	93.43	0,000	20.0	19.0	19.5	98.98	+ 5.55

TABLE 7.

Change of Pressures and Repeated Movements. (Subject *T*.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	18.5	18.6	18.6	100.00	0,000	18.8	18.1	18.5	100.00	0
2	18.5	17.1	17.8	95.70	3,000	18.5	18.1	18.3	99.00	+ 3.30
3	17.0	18.8	17.9	96.24	6,000	19.0	17.4	18.2	98.38	+ 2.14
4	17.5	18.5	18.0	96.77	9,000	19.0	18.4	18.7	101.08	+ 4.31
5	18.5	18.0	18.3	98.39	12,000	18.6	18.2	18.4	99.40	+ 1.07
6	17.5	20.0	18.8	101.08	15,000	19.7	19.0	19.4	104.86	+ 3.78
7	19.0 ¹	18.2	18.6	100.00	18,000	22.3	22.5	22.4	121.68	+ 21.08
8	19.0	19.0	19.0	102.15	21,000	24.0	23.6	23.8	128.65	+ 26.50
9	18.0	20.0	19.0	102.15	18,000	24.0	21.0	22.5	121.62	+ 19.47
10	18.0	19.2	18.6	100.00	15,000	20.2	21.5	20.8	112.43	+ 12.43
11	18.5	20.0	19.3	103.76	12,000	20.0	20.0	20.0	108.11	+ 4.35
12	18.5	20.0	19.2	103.23	9,000	19.0	20.3	19.7	106.49	+ 3.26
13	18.3	18.5	18.4	98.92	6,000	19.5	19.5	19.5	105.41	+ 6.49
14	18.5	18.5	18.5	99.46	3,000	19.5	19.5	19.5	105.41	+ 5.95
15	19.5	19.5	19.5	104.84	0,000	20.0	19.5	19.8	107.03	+ 2.19

¹ Assumed Number.

TABLE 8.
Changes of Pressures and Repeated Movements.
(Subject A.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	21.0	22.0	21.5	100.00	0,000	23.0	21.0	22.0	100.00	0
2	22.0	23.0	22.5	104.65	3,000	22.5	23.0	22.8	103.64	- 1.01
3	24.0	23.2	23.6	109.77	6,000	25.0	24.0	24.0	111.36	+ 1.59
4	23.0	23.0	23.0	106.98	9,000	24.2	23.8	24.0	109.09	+ 2.11
5	23.0	22.8	23.0	106.98	12,000	24.0	24.0	24.0	109.09	+ 2.11
6	25.0	22.0	23.5	109.30	15,000	25.2	25.0	25.1	114.09	+ 4.79
7	23.5	23.0	23.3	108.37	18,000	30.2	25.2	27.7	125.09	+16.72
8	21.8	22.0	21.9	101.86	15,000	27.0	24.0	25.5	115.09	+13.23
9	20.5	24.0	22.3	103.72	12,000	26.5	23.5	25.0	113.64	+ 9.90
10	21.0	23.5	22.3	103.72	9,000	25.2	23.0	24.1	109.55	+ 5.83
11	23.0	24.0	23.5	109.30	6,000	25.5	25.0	25.3	115.00	+ 5.70
12	20.5	22.5	21.5	100.00	3,000	25.0	23.0	24.0	109.09	+ 9.09
13	22.0	22.0	22.0	102.03	0,000	23.5	21.8	22.7	103.18	+ 1.15

TABLE 9.
Changes of Pressures and Repeated Movements.
(Subject H.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	19.0	18.5	18.8	100.00	0,000	19.0	18.3	18.7	100.00	0
2	19.5	18.0	18.8	100.00	3,000	18.5	19.0	19.0	101.60	+ 1.60
3	18.0	18.3	18.2	96.81	6,000	20.0	18.5	19.3	103.21	+ 6.40
4	18.5	18.5	18.5	98.40	9,000	18.5	19.0	18.8	100.53	+ 2.13
5	19.2	18.5	18.9	100.53	12,000	20.0	19.0	19.5	104.28	+ 3.75
6	19.2	18.2	18.7	99.47	15,000	19.0	19.2	19.4	103.74	+ 4.27
7	20.0	18.5	19.3	102.66	18,000	22.0	20.5	21.8	116.58	+13.92
8	18.8	18.5	18.7	99.47	15,000	20.0	18.5	19.3	103.21	+11.13
9	19.0	18.5	18.8	100.00	12,000	19.0	19.0	19.3	103.21	+ 3.21
10	19.2	19.0	19.1	101.61	9,000	19.0	19.0	19.5	104.28	+ 2.68
11	19.0	19.0	19.0	101.06	6,000	19.5	18.8	19.2	102.67	+ 1.61
12	19.0	18.8	18.9	100.53	3,000	20.0	18.2	19.1	102.14	+ 1.61
13	18.5	18.5	18.5	98.40	0,000	20.0	18.5	19.3	103.21	+ 4.81

TABLE IO.

Changes of Pressures and Choice Reaction Time. (Subject W.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	26.0	25.5	25.8	100.00	0,000	27.0	24.2	25.6	100.00	0
2	25.5	25.0	25.3	98.06	3,000	27.2	25.0	26.1	101.95	+ 3.89
3	25.0	25.0	25.0	96.90	6,000	26.0 ¹	25.0	26.0	101.56	+ 4.66
4	25.0	26.2	25.6	99.22	9,000	26.5	26.0	26.3	102.73	+ 3.51
5	25.5	26.5	26.0	100.78	12,000	26.5	27.0	26.8	104.69	+ 5.47
6	27.0	25.0	26.0	100.78	15,000	28.0	27.8	27.9	108.98	+ 9.76
7	27.0	26.2	26.6	103.10	18,000	31.8 ¹	28.0	30.4	118.75	+15.65
8	27.0	26.8	26.9	104.26	21,000	35.5 ²	29.5	33.5	130.86	+26.60
9	27.0	25.0	26.0	100.78	18,000	28.0 ¹	30.0	29.5	114.84	+14.06
10	27.5	25.0	26.3	101.94	15,000	28.0	31.5 ¹	30.3	118.36	+16.42
11	26.0	26.8 ¹	26.9	104.26	12,000	28.5 ¹	27.5	28.5	111.33	+ 7.07
12	26.5	26.2	26.4	102.33	9,000	28.2	26.0 ¹	27.6	107.81	+ 5.48
13	26.0	25.0	26.5	102.71	6,000	28.0	27.0	27.5	107.42	+ 4.71
14	27.0	25.0	26.5	102.71	3,000	27.5	26.0	26.8	104.69	+ 1.98
15	25.8	25.5	25.7	99.61	0,000	26.8	26.2	26.5	103.52	+ 3.91

TABLE II.

Changes of Pressures and Choice Reaction Time. (Subject E.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	28.0	25.0	26.5	100.00	0,000	27.8	25.5	26.7	100.00	0
2	27.5	25.5	26.5	100.00	3,000	28.0	25.5	26.8	100.37	+ 0.37
3	27.0	26.5	26.8	101.13	6,000	28.0	26.8	27.4	102.62	+ 1.49
4	27.0	27.0 ²	28.0	105.66	9,000	32.0 ¹	25.0	29.0	108.61	+ 2.95
5	26.0	27.0 ¹	27.0	101.89	12,000	28.0	27.5	27.8	104.12	+ 2.23
6	25.5	25.5	25.5	96.23	15,000	27.0	28.0	27.5	103.00	+ 6.77
7	28.1	25.5	26.8	101.13	18,000	33.0 ²	28.0 ²	32.5	121.72	+20.59
8	28.5	27.5	28.0	105.66	21,000	49.0 ¹	*44.7 ¹	50.9	190.63	+84.97
9	26.7	26.2 ¹	27.0	101.89	18,000	42.0 ²	31.0 ²	39.5	147.94	+46.05
10	29.0	25.0	27.5	103.77	15,000	31.5 ²	29.5 ³	33.0	123.69	+19.92
11	26.0	25.0	25.5	96.23	12,000	27.0 ¹	27.0 ¹	28.0	104.87	+ 8.64
12	26.0	27.0	26.5	100.00	9,000	29.3	25.5	27.4	102.62	+ 2.62
13	26.0	25.5	25.8	97.34	6,000	26.5	27.0	26.8	100.37	+ 3.03
14	26.8	25.5	26.2	98.87	3,000	28.8	25.0	26.9	100.75	+ 1.88
15	25.5	25.0	25.3	95.47	0,000	28.2	25.2	26.7	100.00	+ 4.53

* Assumed Number.

TABLE 12.

Changes of Pressures and Choice Reaction Time. (Subject *M*.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	33.5 ¹	30.5	32.5	100.00	0,000	33.2	30.5	32.4	100.00	0
2	32.0	32.5	32.3	99.38	3,000	33.2	30.5 ¹	32.4	100.00	+ 0.62
3	31.0	30.8	30.9	95.08	6,000	32.8	31.5	32.2	99.38	+ 4.30
4	32.0	30.0 ¹	31.5	96.92	9,000	34.2	30.2	32.2	99.38	+ 2.42
5	32.0 ¹	30.8	31.7	97.54	12,000	33.5	31.0	32.3	99.69	+ 2.15
6	31.5	30.0	30.8	94.77	15,000	35.0	31.5	33.3	102.78	+ 8.01
7	33.0	30.0	31.5	96.92	18,000	30.2	33.5	34.9	107.72	+ 10.80
8	31.5	30.0	30.8	94.77	21,000	30.5	35.0 ¹	36.3	112.04	+ 17.27
9	31.5	31.5	31.5	96.92	18,000	37.5	37.5	37.5	115.74	+ 18.82
10	31.0	30.0	30.5	93.85	15,000	33.2	33.0	33.1	102.16	+ 8.31
11	30.0	29.5	29.8	90.77	12,000	31.8	30.5	31.2	96.30	+ 5.53
12	31.0 ¹	32.0	32.0	98.46	9,000	34.0 ¹	34.0	34.5	106.48	+ 8.02
13	31.5	32.0	31.8	97.85	6,000	33.0	33.5 ¹	33.8	104.32	+ 6.47
14	30.5	31.5	30.8	94.77	3,000	32.5	33.0	32.8	101.05	+ 6.28
15	30.5	29.5	30.0	92.31	0,000	31.5	31.5	31.5	97.22	+ 4.91

TABLE 13.

Changes of Pressures and Choice Reaction Time. (Subject *T*.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	31.5	29.0	30.3	100.00	0,000	30.8	30.0	30.4	100.00	0
2	31.0	29.5	30.3	100.00	3,000	30.0	30.0	30.0	98.68	- 1.32
3	30.0	28.0	29.0	95.71	6,000	30.0	28.8	29.4	96.71	+ 1.00
4	29.5	28.5	29.0	95.71	9,000	30.8 ¹	29.0	30.4	100.00	+ 4.29
5	31.5 ¹	30.0	30.8	101.65	12,000	32.6 ¹	30.7	32.2	105.92	+ 4.27
6	30.5	28.7	29.6	97.69	15,000	32.6 ¹	29.2	31.9	104.93	+ 7.24
7	30.0	30.0	30.0	99.01	18,000	38.6 ¹	35.5	37.6	123.98	+ 24.67
8	30.0	29.0	29.5	97.36	21,000	44.8 ²	41.4	43.7	143.75	+ 46.37
9	29.5	30.5	30.0	99.01	18,000	37.2	31.0	35.1	115.46	+ 16.45
10	31.0	30.0	30.5	100.66	15,000	34.3	31.0	32.7	107.57	+ 6.91
11	29.0	29.0	29.0	95.71	12,000	30.4	29.0	29.7	97.97	+ 2.26
12	31.5	29.0	30.3	100.00	9,000	31.8	28.5 ¹	30.8	101.31	+ 1.31
13	31.0	31.0	31.0	102.31	6,000	31.6	32.5	32.1	105.57	+ 3.28
14	30.0	30.0	30.0	99.01	3,000	31.6	31.0	31.3	102.96	+ 3.95
15	30.0	30.0	30.0	99.01	0,000	31.0	30.5	30.8	101.31	+ 2.30

* Assumed Number.

TABLE 14.
Changes of Pressures and Choice Reaction Time.
(Subject A.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	32.5	30.2	31.4	100.00	0,000	32.5 ¹	29.5	31.5	100.00	0
2	32.1	32.0 ¹	32.6	103.82	3,000	34.0	31.0	32.5	103.17	- 0.65
3	33.5 ¹	31.5	32.5	103.05	6,000	34.0	35.0	34.5	109.52	+ 6.47
4	31.5	29.2	30.4	96.82	9,000	32.8	31.5	32.2	102.21	+ 5.39
5	35.0	34.5	34.8	110.83	12,000	37.5	38.0	37.8	120.00	+ 9.17
6	31.2	32.0	31.6	100.64	15,000	35.0 ¹	36.0 ¹	36.5	115.87	+ 15.23
7	33.5	32.5	33.0	105.01	18,000	50.0 ¹	39.2	45.1	146.43	+ 41.42
8	32.0	31.0	31.5	100.32	15,000	48.0	37.8	42.9	136.19	+ 35.68
9	31.0	33.8	32.4	103.18	12,000	37.0	33.5	35.3	112.66	+ 8.88
10	33.0	32.5	32.8	104.46	9,000	36.5	33.0	34.8	110.48	+ 6.02
11	35.5	32.0	33.8	107.64	6,000	37.2	33.0	35.1	111.43	+ 3.79
12	32.5	34.5	33.5	106.69	3,000	35.0	35.0	35.0	111.11	+ 4.42
13	34.0	33.0	33.5	106.69	0,000	35.5	33.5	34.5	109.52	+ 2.83

TABLE 15.
Changes of Pressures and Choice Reaction Time.
(Subject H.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	30.0	29.0	29.5	100.00	0,000	29.0	28.5	28.8	100.00	0
2	30.0	29.8	29.9	101.36	3,000	33.0	28.2	30.6	106.25	+ 4.89
3	29.5	28.0	28.8	97.63	6,000	31.5	28.5	30.0	104.17	+ 6.54
4	29.5	30.0	28.8	101.02	9,000	32.2	28.0	30.1	104.51	+ 3.49
5	30.5	28.6	29.6	100.34	12,000	31.0	29.0	30.0	104.17	+ 3.83
6	29.0	29.4	29.2	98.98	15,000	32.2	28.0	30.1	104.51	+ 5.53
7	30.8	29.0	29.9	101.36	18,000	41.5 ³	32.0 ¹	38.8	134.72	+ 33.36
8	30.5	29.0	29.8	101.02	15,000	32.5	31.2	31.9	110.76	+ 9.64
9	30.2	28.5	29.4	99.66	12,000	33.5	29.2	31.4	109.93	+ 9.37
10	28.5	28.8	28.7	97.29	9,000	31.5	28.4	30.0	104.17	+ 5.91
11	28.5	28.2	28.4	96.27	6,000	31.5 ¹	28.4	30.5	105.90	+ 9.60
12	31.0	28.8	29.9	101.36	3,000	32.5	28.5	30.5	105.90	+ 4.54
13	30.5	28.8	29.7	100.68	0,000	31.0	28.2	29.6	102.78	+ 2.10

TABLE 16.

Changes of Pressures and Addition Time. (Subject W.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	25.5	28.5	27.0	100.00	0,000	28.0	26.0	27.0	100.00	0
2	25.0 ¹	28.2 ¹	26.6	98.52	3,000	29.5 ¹	26.0 ¹	27.8	102.96	+ 6.44
3	25.2 ¹	28.0	26.6	98.52	6,000	28.2	29.2	28.7	106.39	+ 7.87
4	29.0	25.2	27.1	100.37	9,000	27.0	29.0	28.0	103.70	+ 3.33
5	28.5	25.5 ¹	27.0	100.00	12,000	33.0	26.0	29.5	109.26	+ 9.26
6	28.0	24.0	26.0	96.30	15,000	29.0	27.0	28.0	103.70	+ 7.40
7	30.8	25.5 ¹	28.2	104.44	18,000	31.5 ¹	33.0 ¹	32.3	119.63	+ 15.19
8	30.0	28.0	29.0	107.41	21,000	35.5 ³	33.5 ²	34.5	127.78	+ 20.37
9	25.5 ¹	27.5	26.5	98.15	18,000	30.5 ¹	30.5 ¹	30.5	112.96	+ 14.81
10	27.0	28.8 ¹	27.9	103.33	15,000	32.2 ³	28.5	30.4	112.59	+ 9.26
11	28.0	26.0	27.0	100.00	12,000	32.0	29.5	30.8	114.07	+ 14.07
12	28.5	29.0	28.8	106.67	9,000	30.5	32.5	31.5	116.67	+ 10.00
13	26.5 ¹	29.2 ¹	27.9	103.33	6,000	29.0	32.5	30.8	114.07	+ 10.74
14	26.5 ¹	29.0 ¹	27.8	102.96	3,000	29.5	27.0 ¹	28.3	104.81	+ 1.85
15	24.5 ¹	27.0 ¹	26.0	96.30	0,000	29.0 ²	23.5 ¹	26.3	97.41	+ 1.11

TABLE 17.

Changes of Pressures and Addition Time. (Subject E.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	39.5	37.0	38.3	100.00	0,000	40.0 ¹	36.0	38.0	100.00	0
2	39.5	38.5	39.0	101.83	3,000	42.5	36.0	39.3	103.42	+ 1.59
3	44.5	36.0 ¹	40.3	105.22	6,000	44.2	40.2	42.1	110.78	+ 5.56
4	43.0 ¹	35.0 ¹	39.0	101.83	9,000	52.0	34.5	43.3	113.95	+ 12.12
5	37.0	36.0	36.5	95.30	12,000	42.0 ¹	38.0	40.0	105.20	+ 9.96
6	38.0	35.5	36.8	96.08	15,000	44.0 ¹	38.0	41.0	107.80	+ 11.81
7	41.0	37.5	39.3	102.61	18,000	66.0 ⁴	46.5 ¹	56.3	148.10	+ 45.55
8	45.0 ¹	35.0 ¹	40.0	104.44	21,000	127.0 ^{4*}	110.4 ²	118.7	312.78	+ 207.93
9	44.0 ²	36.0	40.0	104.44	18,000	87.0 ¹	61.0 ²	74.0	194.74	+ 90.30
10	39.0	32.5	35.8	93.47	15,000	55.0 ¹	38.5	46.8	123.16	+ 29.69
11	44.5 ¹	37.0 ¹	40.8	106.53	12,000	57.0 ¹	38.0	42.5	111.84	+ 5.31
12	42.2	38.5	40.4	105.48	9,000	57.2 ²	36.0	46.6	122.03	+ 17.15
13	45.5	38.0	41.8	109.14	6,000	51.2	39.5	45.4	119.47	+ 10.33
14	41.0	39.0	40.0	104.44	3,000	50.5	40.0	45.3	119.21	+ 14.77
15	38.0 ¹	41.5	39.8	103.92	0,000	48.0	40.0	44.0	115.79	+ 11.87

* Assumed Number.

TABLE 18.

Changes of Pressures and Addition Time. (Subject *M*.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	52.5	49.5 ¹	51.0	100.00	0,000	55.5	47.0	51.3	100.00	0
2	53.0 ¹	46.0	49.5	97.06	3,000	51.0	44.0	47.5	92.59	- 0.47
3	55.0	48.0	51.5	100.98	6,000	60.0	55.0	57.5	112.09	+11.11
4	56.0	49.5	52.8	103.53	9,000	58.0	51.0	54.5	106.24	+ 2.71
5	52.0	48.0	51.0	98.04	12,000	57.0	46.0	51.5	100.39	+ 2.35
6	53.0	56.5 ¹	54.8	107.45	15,000	71.0 ¹	52.5	61.8	120.47	+13.02
7	59.0	48.0	49.0	96.08	18,000	58.2	56.0	57.1	113.45	+17.37
8	54.0 ¹	51.5	52.8	103.53	21,000	121.0 ²	123.0 ⁵	122.0	237.82	+134.29
9	48.0	47.0 ¹	47.5	93.14	18,000	64.0	58.5	61.3	119.49	+20.35
10	49.0	60.0	54.5	106.86	15,000	63.0	67.0	65.0	126.51	+19.65
11	43.5	58.5	51.0	100.00	12,000	59.5	51.0	55.3	107.80	+ 7.80
12	58.0	49.0	53.5	104.90	9,000	63.0	61.5 ¹	62.3	121.44	+16.54
13	49.0	53.0	51.0	100.00	6,000	60.0 ¹	51.5 ¹	55.8	108.77	+ 8.77
14	47.0	56.0	51.5	100.98	3,000	60.0	52.0	56.0	109.16	+ 8.18
15	46.0 ¹	49.5	47.8	93.73	0,000	54.0	46.0	50.0	97.47	+ 3.74

TABLE 19.

Changes of Pressures and Addition Time. (Subject *T*.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	52.0 ¹	49.0	50.5	100.00	0,000	52.2 ¹	47.5	49.9	100.00	0
2	46.5	46.5	46.5	92.08	3,000	46.2	42.0	44.1	88.38	- 3.70
3	53.5	45.0 ¹	49.3	97.62	6,000	50.0	51.5 ¹	50.8	101.80	+ 4.18
4	46.0	44.5	45.3	89.70	9,000	48.4	44.0	46.2	92.59	+ 2.89
5	45.0 ¹	40.0 ¹	42.5	84.16	12,000	50.0	51.5 ¹	50.8	101.80	+17.64
6	45.0	43.0 ¹	44.0	87.13	15,000	45.8 ¹	49.0	47.4	94.99	+ 7.86
7	45.0	43.0 ¹	44.0	87.13	18,000	75.7 ²	62.0 ²	68.9	138.08	+50.95
8	54.5	55.0	54.8	108.51	21,000	95.8 ³	*97.8 ³	96.8	193.99	+85.48
9	51.0 ¹	46.0	48.5	96.05	18,000	70.0 ²	79.0 ²	74.5	149.30	+53.25
10	47.0	45.5	46.3	91.68	15,000	54.8 ¹	58.5	56.7	113.63	+21.95
11	50.0	43.0	46.5	92.08	12,000	44.4	55.0 ¹	49.7	99.60	+ 7.52
12	42.5	44.5	43.5	86.14	9,000	45.0	54.0	49.5	99.20	+13.06
13	47.3 ¹	45.0	46.2	91.49	6,000	53.2	54.0	53.6	107.42	+15.93
14	52.5	45.5	49.0	97.03	3,000	48.8	49.5 ¹	49.2	98.60	+ 1.57
15	53.5	45.0	49.3	97.62	0,000	51.0 ¹	50.5	50.8	101.80	+ 4.18

* Assumed Number.

TABLE 20.
Changes of Pressures and Addition Time.
(Subject A.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	31.5 ¹	41.0 ¹	36.3	100.00	0,000	37.5	35.5 ¹	36.5	100.00	0
2	32.0	37.0 ¹	34.5	95.04	3,000	40.0 ¹	34.0 ¹	37.0	101.37	+ 6.33
3	42.0	38.5	40.3	111.02	6,000	48.5	39.0	43.8	120.00	+ 8.98
4	32.2	38.0	35.1	96.69	9,000	43.0	36.8	39.9	109.32	+ 12.63
5	35.0	38.0	36.5	100.55	12,000	54.0	34.0	44.0	120.55	+ 20.00
6	35.0	36.8 ¹	35.9	98.90	15,000	51.0	40.0 ²	45.5	124.66	+ 25.76
7	37.5 ¹	37.8	37.7	103.86	18,000	68.5 ²	46.5 ³	57.5	157.53	+ 53.67
8	42.5	37.0 ¹	39.8	109.67	15,000	57.0 ²	45.5 ¹	51.3	140.15	+ 30.88
9	41.0	37.0	39.0	107.44	12,000	43.0 ²	48.0	46.5	125.40	+ 17.96
10	41.0	41.5	41.3	113.77	9,000	53.0	44.0	48.5	152.88	+ 39.11
11	39.0	42.0	40.5	111.57	6,000	44.8 ¹	46.5 ¹	45.7	125.21	+ 13.64
12	39.0	30.0 ¹	39.0	107.44	3,000	46.0	45.0	45.5	124.66	+ 17.22
13	40.5 ¹	42.0 ¹	41.3	113.77	0,000	54.0	38.0 ¹	46.0	126.03	+ 12.26

TABLE 21.
Changes of Pressures and Addition Time.
(Subject H.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	51.0 ²	46.0 ¹	48.5	100.00	0,000	57.0 ¹	41.0	49.0	100.00	0
2	56.5 ¹	51.0 ¹	53.8	110.93	3,000	62.0 ²	54.5	58.3	118.98	+ 8.05
3	51.0	51.5 ²	51.3	105.77	6,000	61.0 ¹	50.0	55.5	113.27	+ 7.50
4	51.5	51.5 ¹	51.5	106.02	9,000	52.0 ²	54.0	53.0	108.16	+ 2.14
5	51.5	53.0 ¹	52.3	107.84	12,000	56.0 ¹	55.0	55.5	113.27	+ 5.33
6	54.0	49.5 ²	51.8	106.80	15,000	73.5 ²	54.0 ¹	63.8	130.20	+ 23.40
7	55.0	44.0	49.5	102.06	18,000	75.0 ³	62.0 ¹	68.5	139.80	+ 37.74
8	53.0	50.0	51.5	106.02	15,000	62.5 ²	53.5 ³	58.0	118.37	+ 12.35
9	51.0	43.0	47.0	96.91	12,000	58.0	49.0 ¹	53.5	106.02	+ 12.11
10	55.0 ¹	49.3	52.3	107.84	9,000	60.0	54.5 ¹	57.3	116.94	+ 9.10
11	52.0 ¹	50.0	51.0	105.15	6,000	67.0 ²	49.5 ¹	58.3	118.08	+ 13.83
12	54.5 ²	52.0 ¹	53.3	109.90	3,000	56.0 ¹	54.0 ¹	55.0	112.24	+ 2.34
13	59.0 ¹	49.0	54.0	111.34	0,000	65.0	55.0 ²	60.0	122.45	+ 11.11

TABLE 22.

Changes of Pressures and Memory. (Subject *W.*)

Tests	Control Exp.				Tank Exp.					Diff. of %
	I	II	Av.	%	Feet	I	II	Av.	%	
1	45.0	44.0	44.5	100.00	0,000	43.0	43.0	43.5	100.00	0
2	43.0	42.0	42.5	95.50	3,000	40.0	46.0	43.0	98.86	+ 3.36
3	45.0	48.0	46.5	104.49	6,000	40.0	44.0	42.0	96.56	- 7.93
4	45.0	45.0	45.0	101.12	9,000	37.0	36.0	36.5	83.91	-17.21
5	41.0	46.0	43.5	97.75	12,000	40.0	42.0	41.0	94.26	- 3.49
6	40.0	39.0	39.5	88.76	15,000	30.0	41.0	35.5	81.62	- 7.14
7	42.0	37.0	39.5	88.76	18,000	25.0	37.0	31.0	71.27	-17.49
8	40.0	38.0	39.0	87.63	21,000	27.0	28.0	27.5	63.22	-24.41
9	41.0	41.0	41.0	92.13	18,000	26.0	35.0	30.5	70.12	-22.01
10	40.0	37.0	38.5	86.51	15,000	33.0	37.0	34.0	78.17	- 8.36
11	40.0	40.0	40.0	89.88	12,000	36.0	37.0	36.5	83.91	- 5.97
12	36.0	45.0	40.5	91.00	9,000	31.0	44.0	37.5	86.21	- 4.79
13	37.0	43.0	43.5	97.75	6,000	40.0	42.0	41.0	94.26	- 3.49
14	43.0	44.0	43.5	97.75	3,000	45.0	44.0	44.5	102.31	+ 4.56
15	41.0	45.0	43.0	96.62	0,000	36.0	51.0	43.5	100.00	+ 3.38

TABLE 23.

Changes of Pressures and Memory. (Subject *E.*)

Tests	Control Exp.				Tank Exp.					Diff. of %
	I	II	Av.	%	Feet	I	II	Av.	%	
1	58	58	57.0	100.00	0,000	54.0	56.0	55.0	100.00	0
2	60	58	59.0	103.51	3,000	53.0	58.0	55.5	100.91	- 2.60
3	56	56	56.0	98.25	6,000	58.0	60.0	59.0	107.27	+ 9.02
4	60	58	59.0	103.51	9,000	55.0	56.0	55.5	100.91	- 2.60
5	55	54	54.5	95.62	12,000	51.0	50.0	50.5	91.82	- 3.80
6	58	54	56.0	98.25	15,000	52.0	54.0	53.0	96.37	- 1.88
7	58	58	58.0	101.76	18,000	56.0	54.0	55.0	100.00	- 1.76
8	55	56	55.5	97.37	21,000	30.0	*33.3	31.7	57.64	-39.73
9	54	60	57.0	100.00	18,000	49.0	54.0	51.5	93.64	- 6.36
10	58	58	58.0	101.76	15,000	50.0	57.0	53.5	97.27	- 4.49
11	56	60	58.0	101.76	12,000	49.0	50.0	49.5	90.00	-11.76
12	60	52	56.0	98.25	9,000	56.0	56.0	56.0	101.82	+ 3.57
13	54	56	55.0	96.49	6,000	54.0	55.0	54.5	99.09	+ 2.60
14	54	56	55.0	96.49	3,000	53.0	54.0	53.5	97.27	+ 0.78
15	60	58	59.0	103.51	0,000	55.0	53.0	54.0	98.18	- 5.33

* Assumed Number.

TABLE 24.

Changes of Pressures and Memory. (Subject *M.*)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	26.0	32.0	29.0	100.00	0,000	24.0	30.0	27.0	100.00	0
2	23.0	28.0	25.5	86.92	3,000	22.0	25.0	23.5	87.02	+ 0.10
3	19.0	31.0	25.0	86.20	6,000	20.0	30.0	25.0	92.60	+ 6.40
4	28.0	25.0	26.5	91.37	9,000	22.0	26.0	24.0	88.91	- 2.46
5	—	—	—	—	12,000	—	—	—	—	—
6	28.0	30.0	29.0	100.00	15,000	18.0	30.0	24.0	88.91	- 11.09
7	28.0	30.0	29.0	100.00	18,000	25.0	28.0	26.5	98.16	- 1.84
8	30.0	28.0	29.0	100.00	21,000	20.0	19.0	19.5	72.23	- 27.77
9	28.0	32.0	30.0	103.44	18,000	23.0	26.0	24.5	90.76	- 12.68
10	30.0	26.0	28.0	96.54	15,000	22.0	28.0	25.0	92.60	- 3.94
11	—	—	—	—	12,000	—	—	—	—	—
12	27.0	26.0	26.5	91.37	9,000	19.0	30.0	24.5	90.76	- 0.61
13	30.0	26.0	28.0	96.54	0,000	24.0	27.0	25.5	94.45	- 2.09
14	27.0	32.0	29.5	101.72	3,000	25.0	26.0	25.5	94.45	- 7.24
15	32.0	28.0	30.0	103.44	0,000	32.0	25.0	28.5	105.56	+ 2.12

TABLE 25.

Changes of Pressures and Memory. (Subject *T.*)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	40.0	38.0	39.0	100.00	0,000	37.0	37.0	37.0	100.00	0
2	39.0	38.0	38.5	98.71	3,000	38.0	37.0	37.5	100.36	+ 2.65
3	36.0	39.0	37.5	96.15	6,000	34.0	40.0	37.0	100.00	+ 3.85
4	40.0	49.0	40.0	102.56	9,000	35.0	36.0	35.5	95.93	- 6.63
5	34.0	43.0	38.5	98.71	12,000	32.0	37.0	34.5	93.25	- 5.46
6	39.0	38.0	38.5	98.71	15,000	31.0	34.0	32.5	87.83	- 10.88
7	37.0	36.0	36.5	93.59	18,000	35.0	28.0	31.5	84.15	- 9.44
8	34.0	37.0	35.5	91.03	21,000	22.0	*22.9	22.5	60.80	- 30.23
9	36.0	37.0	36.5	93.59	18,000	26.0	33.0	29.5	79.73	- 13.86
10	34.0	37.0	35.5	91.03	15,000	30.0	33.0	31.5	84.15	- 5.88
11	35.0	38.0	36.5	93.59	12,000	33.0	34.0	33.5	90.54	- 3.05
12	36.0	41.0	38.5	98.71	9,000	33.0	32.0	32.5	87.83	- 11.88
13	30.0	36.0	36.5	92.30	0,000	33.0	34.0	33.5	90.54	- 1.76
14	33.0	45.0	39.5	100.00	3,000	37.0	35.0	36.0	97.31	- 2.69
15	37.0	39.0	38.5	97.43	0,000	35.0	38.0	36.5	98.66	- 1.23

* An Assumed Number.

TABLE 26.
Changes of Pressures and Memory.
(Subject A.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	47.0	53.0	50.0	100.00	0,000	52.0	50.0	51.0	100.00	0
2	42.0	51.0	46.5	93.00	3,000	41.0	54.0	47.5	93.14	+ 0.14
3	55.0	46.0	50.5	101.00	6,000	50.0	43.0	46.5	91.18	- 0.82
4	45.0	46.0	45.5	91.00	9,000	40.0	45.0	42.5	83.33	- 7.07
5	48.0	52.0	50.0	100.00	12,000	46.0	54.0	50.0	98.04	- 1.96
6	51.0	47.0	49.0	98.00	15,000	43.0	46.0	44.5	87.25	- 10.75
7	48.0	52.0	50.0	100.00	18,000	43.0	47.0	45.5	89.28	- 10.78
8	47.0	47.0	47.0	94.00	15,000	46.0	42.0	44.0	86.28	- 7.72
9	56.0	47.0	51.5	103.00	12,000	52.0	47.0	49.5	97.00	- 5.94
10	47.0	49.0	48.0	96.00	9,000	46.0	45.0	45.5	89.22	- 6.78
11	49.0	52.0	50.5	101.00	6,000	52.0	49.0	50.5	99.02	- 1.98
12	48.0	52.0	50.0	100.00	3,000	49.0	52.0	50.5	99.02	- 0.98
13	50.0	56.0	53.0	106.00	0,000	55.0	47.0	51.0	103.00	- 6.00

TABLE 27.
Changes of Pressures and Memory.
(Subject H.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	25.0	38.0	31.5	100.00	0,000	23.0	39.0	31.0	100.00	0
2	27.0	32.0	29.5	93.65	3,000	24.0	36.0	30.0	90.77	+ 3.12
3	24.0	40.0	32.0	101.59	6,000	25.0	40.0	32.5	104.84	+ 3.25
4	26.0	38.0	32.0	101.59	9,000	23.0	38.0	30.5	98.39	- 3.20
5	26.0	38.0	32.0	101.59	12,000	24.0	38.0	31.0	100.00	- 1.59
6	24.0	41.0	32.5	103.18	15,000	22.0	40.0	31.0	100.00	- 3.18
7	27.0	37.0	32.0	101.59	18,000	20.0	24.0	22.0	70.97	- 30.62
8	28.0	44.0	36.0	104.29	15,000	22.0	39.0	30.5	98.39	- 5.90
9	26.0	41.0	36.5	105.86	12,000	24.0	38.0	31.0	100.00	- 5.86
10	24.0	38.0	31.0	98.41	9,000	24.0	37.0	30.5	98.39	- 0.02
11	21.0	38.0	29.5	93.65	6,000	20.0	34.0	27.0	87.10	- 6.55
12	26.0	38.0	32.0	101.59	3,000	28.0	36.0	32.0	103.23	+ 1.64
13	28.0	42.0	35.0	111.11	0,000	29.0	40.0	34.5	111.29	+ 0.18

TABLE 28.

Changes of Pressures and Grips. (Subject. IV.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	127.5	125.5	126.5	100.00	0,000	127.5	124.5	126.0	100.00	0
2	128.0	127.5	127.8	101.03	3,000	128.5	124.5	126.5	100.40	+ 0.63
3	126.5	126.0	126.3	99.92	6,000	128.5	125.5	127.0	100.80	- 0.88
4	125.0	127.0	126.0	99.69	9,000	129.0	124.0	126.5	100.40	- 1.60
5	122.5	126.5	126.0	99.60	12,000	128.5	124.0	126.3	100.24	- 0.64
6	123.0	125.5	124.3	98.27	15,000	128.5	125.0	126.3	100.24	- 1.97
7	125.0	126.0	125.5	99.13	18,000	126.5	126.5	126.5	100.40	- 1.27
8	125.5	125.5	125.5	99.13	21,000	130.0	124.5	127.3	101.03	- 1.99
9	125.0	126.0	125.5	99.13	18,000	130.0	123.0	126.5	100.40	- 1.27
10	122.5	125.5	124.0	98.02	15,000	130.0	123.5	126.8	100.64	- 2.62
11	123.0	126.0	124.5	98.42	12,000	128.5	122.5	125.5	99.60	- 1.18
12	125.0	124.0	124.5	98.42	9,000	127.0	124.5	125.8	99.84	- 1.42
13	123.5	124.5	124.0	98.02	6,000	124.5	126.0	125.3	99.44	- 1.42
14	122.5	128.5	125.5	99.13	3,000	124.0	125.5	124.8	99.05	+ 0.08
15	125.5	127.0	126.3	99.92	0,000	126.5	125.5	126.0	100.00	- 0.08

TABLE 29.

Changes of Pressures and Grips. (Subject E.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	119.0	121.0	119.0	100.00	0,000	121.0	121.0	121.0	100.00	0
2	119.5	119.0	119.3	100.25	3,000	123.0	121.5	122.3	101.07	+ 0.82
3	120.5	121.0	120.8	101.51	6,000	121.5	120.0	120.8	99.83	- 1.68
4	116.5	119.0	117.8	99.90	9,000	121.5	122.0	121.8	100.66	+ 1.66
5	118.5	119.5	119.0	100.00	12,000	121.0	123.0	122.0	100.83	+ 0.83
6	116.0	118.5	117.3	98.57	15,000	120.0	119.0	119.5	98.76	+ 0.19
7	116.0	121.0	118.5	99.58	18,000	115.0	118.5	116.8	96.53	- 3.05
8	119.5	121.0	120.3	101.09	21,000	117.5	*116.7	117.1	96.78	- 4.31
9	115.0	123.5	119.3	100.25	18,000	120.0	115.0	117.5	97.11	- 3.14
10	115.0	125.0	120.0	100.84	15,000	121.5	117.5	119.5	98.76	- 2.08
11	115.0	125.0	120.0	100.84	12,000	117.5	115.5	116.5	96.28	- 4.56
12	115.5	120.5	117.0	99.16	9,000	117.5	122.5	120.0	99.17	+ 0.01
13	118.0	121.5	119.8	100.67	6,000	121.5	121.0	121.3	100.25	- 0.42
14	114.0	126.0	120.0	100.84	3,000	118.5	119.0	118.8	98.18	- 2.66
15	117.5	126.0	121.8	102.35	0,000	121.0	120.0	120.5	99.59	- 2.76

* Assumed Number.

TABLE 30.

Changes of Pressures and Grips. (Subject *M.*)

Tests	Control Exp.				Tank Exp.					Diff. of %
	I	II	Av.	%	Feet	I	II	Av.	%	
1	129.0	131.0	130.0	100.00	0,000	129.0	132.5	130.8	100.00	0
2	135.0	140.0	137.5	105.77	3,000	138.5	137.5	138.0	105.77	- 0.27
3	137.5	142.5	140.0	107.69	6,000	145.0	141.5	143.3	107.69	+ 1.87
4	138.0	139.0	138.5	106.54	9,000	145.5	142.0	143.8	106.54	+ 3.40
5	137.0	136.0	136.5	105.00	12,000	140.5	143.0	141.8	105.00	+ 3.41
6	136.0	134.5	135.5	104.23	15,000	144.5	137.5	141.0	104.23	+ 3.57
7	134.0	138.5	136.3	104.85	18,000	143.5	137.0	140.6	104.85	+ 2.64
8	136.5	133.5	135.0	103.85	21,000	133.0	123.0	128.0	103.85	- 5.99
9	135.0	136.5	135.8	104.46	18,000	142.5	130.0	136.3	104.46	- 0.26
10	138.0	135.0	136.5	105.00	15,000	135.5	131.5	133.5	105.00	- 2.94
11	136.5	134.0	135.3	104.08	12,000	136.0	136.0	136.0	104.08	- 0.10
12	135.0	131.5	133.3	102.54	9,000	132.5	134.5	133.5	102.54	- 0.48
13	135.0	136.0	135.5	104.23	6,000	130.0	133.5	131.8	104.23	- 3.47
14	131.5	132.5	132.0	101.54	3,000	130.5	126.5	128.5	101.54	- 3.30
15	138.5	132.0	135.3	104.04	0,000	135.0	129.5	132.3	104.08	- 2.93

TABLE 31.

Changes of Pressures and Grips. (Subject *T.*)

Tests	Control Exp.				Tank Exp.					Diff. of %
	I	II	Av.	%	Feet	I	II	Av.	%	
1	126.0	125.0	125.5	100.00	0,000	135.0	122.3	128.7	100.00	0
2	126.3	123.7	125.0	99.60	3,000	131.3	122.3	126.8	98.52	- 1.08
3	127.3	124.0	125.7	100.16	6,000	131.7	120.3	126.0	97.90	- 2.26
4	124.3	125.0	124.7	99.36	9,000	132.7	120.0	126.4	98.23	- 1.13
5	124.7	123.0	123.9	98.73	12,000	131.0	119.3	125.2	97.22	- 1.51
6	127.0	119.0	123.0	98.01	15,000	128.0	116.3	122.2	94.95	- 3.06
7	126.0	117.3	121.7	96.97	18,000	128.3	111.3	119.8	93.26	- 3.71
9	124.3	121.0	122.7	97.77	21,000	125.7	111.2	118.5	92.07	- 5.70
9	123.3	120.0	121.7	96.97	18,000	126.7	106.0	116.4	90.44	- 6.53
10	121.3	115.3	118.3	94.26	15,000	130.7	107.3	119.0	92.62	- 1.61
11	121.0	113.7	117.4	93.55	12,000	126.7	110.7	118.7	92.39	- 1.16
12	121.3	115.7	118.5	94.42	9,000	131.0	110.0	120.5	93.63	- 0.79
13	120.7	116.0	118.4	94.34	0,000	124.3	112.7	118.5	92.25	- 2.09
14	120.7	112.7	116.7	92.99	3,000	126.7	109.3	118.0	91.69	- 1.30
15	121.0	113.3	117.2	93.99	6,000	126.0	113.3	119.7	93.01	- 0.38

* Assumed Number.

TABLE 32.
Changes of Pressures and Grips.
(Subject A.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	97.5	94.5	96.0	100.00	0 000	100.5	92.5	96.5	100.00	0
2	103.0	91.5	97.3	101.35	3,000	100.0	90.0	95.0	98.45	- 2.90
3	96.0	94.0	95.0	98.96	6,000	96.5	93.5	95.0	98.45	- 0.50
4	97.0	95.0	96.0	100.00	9,000	94.5	91.5	92.8	96.17	- 3.83
5	89.0	90.5	89.8	93.54	12,000	99.0	88.5	93.8	97.20	+ 3.66
6	86.0	93.0	89.5	93.23	15,000	96.5	89.5	93.0	96.37	+ 3.14
7	93.0	91.5	92.3	96.15	18,000	96.0	91.5	93.8	97.20	+ 1.05
8	92.5	87.5	90.0	93.75	15,000	91.0	87.5	89.3	92.54	- 1.21
9	94.0	86.5	90.3	94.06	12,000	92.5	90.0	91.3	94.51	+ 0.45
10	93.0	88.5	90.8	94.58	9,000	91.0	90.0	90.5	93.78	- 0.80
11	90.5	90.0	90.3	94.06	6,000	95.0	85.0	90.0	93.26	- 0.80
12	90.5	94.0	92.3	96.15	3,000	94.0	84.5	89.3	92.54	- 3.61
13	94.5	87.0	90.8	94.58	0,000	94.5	84.5	89.5	92.75	- 1.83

TABLE 33.
Changes of Pressures and Grips.
(Subject H.)

Tests	Control Exp.				Feet	Tank Exp.				Diff. of %
	I	II	Av.	%		I	II	Av.	%	
1	93.0	86.5	89.8	100.00	0 000	101.5	95.0	98.3	100.00	0
2	94.0	85.0	89.5	99.67	3,000	99.5	94.0	96.8	98.47	- 1.20
3	95.0	87.5	91.3	101.67	6,000	101.5	92.5	97.0	98.68	- 2.99
4	92.0	87.5	89.8	100.00	9 000	96.0	93.0	94.5	96.13	- 3.87
5	93.0	86.0	89.5	99.67	12,000	96.5	95.0	95.8	97.46	- 2.21
6	90.0	86.5	88.3	89.33	15,000	93.5	92.5	93.0	94.61	- 3.71
7	88.5	86.0	87.3	97.22	18,000	93.5	97.5	95.5	97.15	- 0.07
8	88.5	85.0	86.8	96.66	15,000	94.5	94.5	94.5	96.13	- 0.53
9	86.5	85.5	86.0	95.77	12,000	93.5	95.0	94.3	95.93	+ 0.16
10	88.5	84.0	88.3	98.33	9,000	93.0	94.0	93.5	95.12	- 3.21
11	88.5	83.5	86.0	95.77	6,000	94.5	95.5	95.0	96.64	+ 0.87
12	86.0	86.0	86.0	96.77	3,000	94.5	94.0	94.3	95.93	+ 0.16
13	85.5	84.5	85.0	94.65	0,000	96.0	92.0	94.0	95.63	- 0.98

TABLE 34.

Altitudes, the Air Pressure and Oxygen Partial Pressure.

Feet	Pressure (mm)	Oxygen (%)	Feet	Pressure (mm)	Oxygen (%)
0,000	760	20.90	16,000	412	11.30
1,000	732	20.15	17,000	397	10.97
2,000	704	19.38	18,000	382	10.59
3,000	677	18.64	19,000	368	10.16
4,000	651	17.93	20,000	354	9.78
5,000	626	17.25	21,000	341	9.41
6,000	602	16.60	22,000	328	9.05
7,000	579	15.97	23,000	315	8.70
8,000	557	15.37	24,000	303	8.35
9,000	536	14.80	25,000	290	8.01
10,000	516	14.25	26,000	278	7.68
11,000	497	13.73	27,000	266	7.35
12,000	478	13.23	28,000	254	7.03
13,000	461	12.75	29,000	242	6.71
14,000	444	12.28	30,000	230	6.41
15,000	428	11.83			

TABLE 35.

Practice Effect in Ergograph.

Subject <i>H.</i> Weight = 46 g. Rhythm = one per second.				Subject <i>T.</i> Weight = 5 Kg. Rhythm = one per second.			
Trials	No. of Contractions	Length of Contractions <i>mm</i>	Amount of Work <i>Kg. mm</i>	Trials	No. of Contractions	Length of Contractions <i>mm</i>	Amount of Work <i>Kg. mm</i>
1	39	672.0	2688	1	46	995.0	4975.0
2	38	774.0	3192	2	41	1101.0	5595.0
3	34	741.0	2988	3	42	1021.0	5195.0
4	36	785.0	3140	4	46	1240.0	6200.0
5	30	714.5	2858	5	37	982.5	4912.5
6	52	1086.0	4344	6	54	1400.0	7000.0
7	52	1062.0	4248	7	52	1499.5	7497.5
8	60	1185.5	4742	8	57	1588.5	7942.5
9	68	1313.0	5252	9	56	1612.5	8062.5
10	72	1292.5	5170	10	58	1633.5	8167.5
11	76	1393.5	5584	11	59	1627.5	8137.5
12	77	1608.0	6432	12	61	1732.0	8660.0
13	76	1537.5	6150	13	61	1813.5	9097.5
14	63	1579.0	6216	14	61	1805.5	9027.5
15	58	1450.0	5800	15	65	1773.0	8865.0
16	71	1500.0	6000	16	66	1886.5	9432.5
17	73	1691.5	6766	—	—	—	—
Diff. 1st and Last	34	1019.5	—	—	20	891.5	—
% of Improvement	87.18	151.71	—	—	43.48	89.60	—

TABLE 36.
Results of Ergographic Experiments.
(Subject H.)

Days	Feet	No. of Contractions	Length of Contractions	Amount of Work
May 19	0	73	<i>mm.</i> 1691.5	<i>Kg. mm.</i> 6766 (I)
22	3,000	72	1792.0	7168
23	6,000	71	1741.0	6964
24	9,000	65	1672.0	6688
26	12,000	66	1727.5	6910
28	0	70	1970.0	7880 (II)
June 4	0	74	2265.5	9062 (III)
5	15,000	68	2177.0	8708
6	18,000	64	1898.0	7592
8	0	75	2192.5	8770 (IV)
15	0	76	2116.5	8466 (V)
16	18,000	75	1965.0	7860
19	15,000	74	2096.0	8384
20	12,000	75	2094.0	8376
21	0	82	2415.0	9660 (VI)
22	9,000	75	2223.5	8894
23	6,000	76	2218.0	8872
25	3,000	76	2373.5	9494
26	0	79	2242.0	8968 (VII)
27	3,000	80	2261.5	9046
28	6,000	73	2231.5	8926
29	9,000	74	2167.0	8668
30	12,000	74	2190.0	8760
July 2	0	85	2328.0	9312 (VIII)
3	15,000	74	2302.5	9210
4	18,000	75	2290.0	9160
7	0	82	2528.0	10112 (IX)

TABLE 36. (Continued)
 Results of Ergographic Experiments.
 (Subject *T.*)

Days	Feet	No. of Contractions	Length of Contractions	Amount of Work
			<i>mm.</i>	<i>Kg. mm.</i>
May 18	0	66	1886.5	9432.5 (I)
19	3,000	65	1889.5	9447.5
22	6,000	66	1902.5	9512.5
23	9,000	64	1891.5	9457.5
24	12,000	68	1785.5	9027.5
25	0	68	1905.0	9525.0 (II)
26	15,000	66	1692.0	8460.0
June 4	0	71	1806.5	9032.5 (III)
5	18,000	61	1570.5	7852.5
6	21,000	48	1284.0	6420.0
8	0	82	1967.5	9837.5 (IV)
14	0	74	1839.5	9197.5 (V)
16	21,000	48	1431.5	7157.5
19	18,000	54	1442.5	7212.5
20	15,000	63	1653.0	8265.0
21	0	81	1961.0	9805.0 (VI)
22	12,000	76	1849.0	9245.0
23	9,000	76	1929.5	9647.5
25	6,000	73	2015.5	10077.5
26	3,000	76	1914.0	9570.0
27	0	77	2022.5	10112.5 (VII)
28	3,000	76	1975.0	9875.0
29	6,000	72	1917.0	9585.0
30	9,000	73	1942.0	9750.0
July 2	0	80	1997.5	9987.5 (VIII)
3	12,000	71	1838.5	9192.5
4	15,000	74	1816.5	9082.5
5	18,000	70	1863.0	9315.0
6	21,000	68	1766.0	8830.0
7	0	84	2080.0	10420.0 (IX)

TABLE 37.

Practice Effect in Reaction Time (Unit= Σ).

Subject *IV*.

Days of Practice	Auditory		Tactile		Visual		Choice	
	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.
1	14.50	1.46	15.17	1.31	17.25	1.49	28.20	5.16
2	12.43	0.95	13.77	0.77	15.99	1.59	16.56	4.16
3	13.55	0.85	13.65	0.77	15.83	1.73	19.80 ⁽¹⁾	2.76
4	13.46	1.44	15.45	1.05	17.70	1.04	21.76	3.40
5	14.58	1.42	16.21	0.99	16.58	0.62	21.20	5.84
6	13.58	0.92	14.68	1.60	16.81	1.73	17.32	0.54
7	13.80	0.72	14.00	0.94	16.85	1.45	17.30 ⁽¹⁾	2.16
Diff. 1st and last	0.70	—	1.17	—	0.40	—	10.90	—
% of Improvement	4.83	—	7.71	—	2.32	—	38.65	—

Subject *M*.

Days of Practice	Auditory		Tactile		Visual		Choice	
	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.
1	15.50	1.44	15.25	1.15	18.90	1.76	25.40 ⁽²⁾	3.05
2	14.55	0.49	13.56	0.80	18.88	1.10	19.10 ⁽²⁾	2.92
3	13.47	1.07	12.60	0.80	18.48	1.22	19.90 ⁽¹⁾	4.44
4	13.81	0.81	12.98	0.37	17.90	0.60	17.90	3.28
5	14.00	0.70	12.50	0.60	18.60	1.04	21.10	5.72
6	14.16	1.32	12.93	1.15	18.30	1.62	18.60 ⁽¹⁾	3.56
7	13.75	1.20	13.40	0.90	17.45	1.65	19.80	4.68
8	13.80	1.18	12.65	1.19	18.10	1.08	18.10	3.21
9	13.80	0.80	12.55	0.61	18.40	0.92	17.70	2.76
Diff. 1st and last	1.70	—	2.70	—	0.50	—	7.70	—
% of Improvement	10.97	—	17.70	—	2.65	—	30.31	—

TABLE 37. (Continued)

Practice Effect in Reaction Time.

Subject *T.*

Days of Practice	Auditory		Tactile		Visual		Choice	
	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.
1	14.60	2.00	15.05	1.47	18.50	1.66	26.80 ⁽¹⁾	7.76
2	14.40	1.64	14.40	0.44	17.80	1.04	24.00 ⁽²⁾	4.40
3	15.70	0.85	14.95	1.05	17.81	1.51	20.00	3.60
4	14.75	1.85	14.93	1.51	16.93	0.93	23.70 ⁽¹⁾	5.24
5	14.85	1.61	15.11	1.23	17.55	0.85	20.60	4.48
6	14.15	0.82	14.10	0.92	17.73	0.67	17.90	0.72
7	13.83	1.07	13.85	1.03	16.85	1.15	18.20	2.32
8	13.98	0.92	14.00	0.90	17.50	0.80	18.10	1.52
9	13.80	1.32	13.85	0.95	17.56	1.50	19.30 ⁽¹⁾	3.30
Diff. 1st and last	0.80	—	1.20	—	0.94	—	5.50	—
% of Improvement	5.48	—	7.97	—	5.08	—	20.52	—

Subject *H.*

Days of Practice	Auditory		Tactile		Visual		Choice	
	Av.	M.V.	Av.	M.V.	Av.	M.V.	Av.	M.V.
1	16.15	1.77	18.90	1.70	19.53	1.63	30.70 ⁽²⁾	3.16
2	13.80	1.06	15.20	1.50	19.20	1.20	22.50	1.00
3	13.84	0.98	14.64	0.54	19.32	0.88	22.26	3.92
4	14.22	0.76	15.68	1.08	18.91	1.11	23.80	6.56
5	14.80	0.70	14.83	1.07	18.78	1.47	18.50	2.80
6	14.01	0.99	15.64	0.88	18.58	0.78	20.96	3.96
7	13.58	0.74	14.45	1.01	18.33	1.45	17.50	0.80
8	13.38	1.10	14.20	0.68	18.75	1.35	19.00 ⁽¹⁾	5.00
9	13.54	0.98	14.21	0.65	18.91	0.98	19.96	0.80
10	13.64	1.07	13.35	1.05	18.42	1.22	18.50	4.60
11	13.97	1.57	16.90	1.60	18.53	0.97	18.20	2.56
12	13.50	1.65	14.80	1.80	19.26	2.52	21.60	2.72
13	13.90	1.07	15.40	1.12	19.30	1.61	18.96	2.44
14	13.41	0.77	14.36	0.80	18.68	0.86	18.70	2.04
15	13.97	0.80	15.33	1.03	18.53	0.97	18.20	2.00
Diff. 1st and last	2.18	—	3.57	—	1.00	—	12.50	—
% of Improvement	13.50	—	18.89	—	5.12	—	40.72	—

TABLE 38.

Changes of Pressures and Auditory Simple Reaction Time.
(Numbers in parentheses are *M.I.*)

Subject *W.*

Feet	I	II	Av.	%
0,000	13.60 (1.30)	13.40 (1.00)	13.50 (1.15)	100.00
6,000	13.28 (1.44)	14.15 (0.95)	13.72 (1.20)	101.63
12,000	13.90 (0.90)	14.30 (1.06)	14.10 (0.98)	104.44
15,000	14.70 (1.36)	14.38 (1.35)	14.54 (1.30)	107.70
18,000	16.50 (2.30)	15.20 (1.44)	15.85 (1.72)	117.41
21,000	()	16.85 (1.83)	16.85 (1.43)	124.81
18,000	()	15.15 (1.73)	15.15 (1.73)	112.22
15,000	16.25 (1.49)	14.25 (1.81)	15.25 (1.65)	112.96
12,000	14.10 (1.12)	13.88 (0.92)	13.99 (1.02)	103.63
6,000	13.88 (0.90)	13.60 (1.32)	13.47 (1.11)	101.78
0,000	13.50 (0.80)	13.60 (0.82)	13.55 (0.81)	100.37

Subject *M.*

Feet	I	II	Av.	%
0,000	12.78 (0.72)	14.03 (1.03)	13.41 (0.87)	100.00
6,000	14.01 (1.01)	14.05 (0.85)	14.03 (0.93)	104.62
12,000	14.82 (0.89)	13.95 (1.45)	14.39 (1.17)	107.31
15,000	14.96 (1.04)	14.98 (0.98)	14.97 (1.01)	111.63
18,000	15.75 (1.79)	15.80 (1.14)	15.78 (1.47)	117.67
21,000	16.70 (1.40)	16.51 (1.65)	16.61 (1.53)	123.86
18,000	17.90 (2.41)	16.10 (1.62)	17.00 (2.02)	126.77
15,000	17.30 (1.64)	14.40 (1.98)	15.85 (1.81)	118.20
12,000	15.75 (1.21)	14.35 (1.15)	15.05 (1.18)	112.23
6,000	15.01 (1.15)	14.35 (0.79)	14.68 (0.97)	109.47
0,000	13.65 (0.81)	14.40 (0.70)	14.03 (0.76)	104.62

TABLE 38. (Continued)

Changes of Pressures and Auditory Simple Reaction Time.

(Number in parentheses are *M. V.*)Subject *T.*

Feet	I	II	Av.	%
0,000	13.65 (0.85)	14.02 (0.45)	13.84 (0.65)	100.00
6,000	14.15 (0.89)	14.17 (0.91)	14.16 (0.90)	102.31
12,000	15.40 (1.58)	14.62 (0.68)	15.01 (1.13)	108.45
15,000	15.60 (1.04)	14.78 (0.74)	15.19 (0.87)	109.75
18,000	16.35 (1.35)	14.89 (1.81)	15.62 (1.58)	112.86
21,000	17.15 (1.43)	16.96 (1.30)	17.06 (1.57)	123.27
18,000	17.50 (0.90)	16.11 (1.63)	16.81 (1.27)	121.46
15,000	17.70 (2.30)	15.10 (1.85)	16.40 (2.08)	118.50
12,000	16.72 (1.94)	16.41 (1.73)	16.57 (1.84)	119.73
6,000	16.28 (1.36)	15.18 (0.62)	15.73 (0.99)	113.66
0,000	14.80 (1.85)	14.65 (0.71)	14.73 (1.28)	106.43

Subject *H.*

Feet	I	II	Av	%
0,000	13.82 (0.98)	12.60 (0.64)	13.21 (0.81)	100.00
6,000	13.88 (0.56)	13.43 (1.11)	13.66 (0.89)	103.41
12,000	14.43 (0.95)	14.05 (1.47)	14.24 (1.21)	107.80
15,000	16.28 (1.20)	14.86 (1.12)	15.57 (1.16)	117.87
18,000	()	15.75 (2.15)	15.75 (2.15)	119.23
21,000	.....	.....	.....	.....
18,000	.....	.....	.....	.....
15,000	()	14.60 (1.22)	14.60 (1.22)	110.52
12,000	15.68 (1.35)	14.68 (1.18)	15.18 (1.27)	114.91
6,000	14.28 (1.26)	13.60 (0.78)	13.94 (1.02)	105.53
0,000	14.81 (1.25)	13.30 (1.20)	14.06 (1.23)	106.43

TABLE 39.

Changes of Pressures and Tactile Simple Reaction Time.

Subject *W.*

Feet	I	II	Av.	%
0,000	14.00 (1.00)	14.45 (1.15)	14.23 (1.08)	100.00
6,000	14.80 (1.14)	14.30 (1.32)	14.55 (1.23)	102.25
12,000	15.60 (1.92)	14.05 (0.75)	14.83 (1.34)	104.22
15,000	16.60 (1.36)	14.70 (1.66)	15.65 (1.51)	109.98
18,000	18.55 (2.63)	16.10 (3.44)	17.33 (3.04)	121.78
21,000	.....	18.90 (2.58)	18.90 (2.58)	132.82
18,000	.....	16.90 (1.92)	16.90 (1.92)	118.76
15,000	18.10 (1.12)	14.50 (0.90)	16.30 (1.01)	114.55
12,000	15.50 (1.10)	14.21 (1.11)	14.88 (1.11)	104.43
6,000	14.15 (1.33)	14.50 (1.54)	14.33 (1.44)	100.70
0,000	14.70 (0.68)	14.20 (1.14)	14.45 (0.91)	101.55

Subject *M.*

Feet	I	II	Av.	%
0,000	12.28 (0.76)	13.46 (1.05)	12.87 (0.91)	100.00
6,000	14.37 (1.49)	13.58 (0.58)	13.98 (1.04)	108.62
12,000	14.86 (1.08)	13.63 (0.87)	14.25 (0.98)	110.71
15,000	14.91 (1.05)	14.93 (0.71)	14.92 (0.88)	115.93
18,000	14.78 (0.88)	16.00 (1.10)	15.39 (0.99)	119.58
21,000	15.55 (0.85)	16.58 (1.58)	16.07 (1.22)	124.86
18,000	15.25 (1.01)	14.45 (1.55)	14.85 (1.33)	115.38
15,000	16.90 (1.46)	14.25 (1.16)	15.58 (1.31)	121.06
12,000	13.50 (1.20)	13.40 (0.54)	13.45 (0.87)	104.51
6,000	13.95 (1.35)	12.45 (1.05)	13.20 (1.20)	102.56
0,000	12.40 (0.59)	13.55 (1.02)	12.98 (0.81)	100.85

TABLE 39. (Continued.)

Changes of Pressures and Tactile Simple Reaction Time.

Subject *T.*

Feet	I	II	Av.	%
0,000	14.58 (1.04)	13.97 (1.17)	14.28 (1.11)	100.00
6,000	15.78 (0.92)	14.91 (0.47)	15.35 (0.65)	107.49
12,000	15.85 (1.25)	14.94 (0.72)	15.40 (0.99)	107.84
15,090	15.55 (1.65)	15.61 (1.07)	15.58 (1.36)	109.10
18,000	16.43 (1.41)	15.75 (1.15)	16.09 (1.28)	111.97
21,000	20.20 (3.54)	19.00 (1.80)	19.60 (2.67)	137.25
18,000	17.85 (1.39)	18.80 (1.64)	18.33 (1.57)	128.36
15,000	16.95 (1.85)	16.74 (1.08)	16.85 (1.47)	118.00
12,000	16.78 (1.48)	16.20 (1.04)	16.49 (1.26)	115.48
6,000	16.34 (1.18)	16.40 (0.72)	16.37 (0.95)	113.94
0,000	14.70 (1.60)	15.53 (0.82)	14.77 (1.21)	103.43

Subject *H.*

Feet	I	II	Av.	%
0,000	14.38 (0.58)	13.98 (1.12)	14.18 (0.85)	100.00
6,000	14.08 (1.04)	14.65 (1.61)	14.37 (1.33)	101.34
12,000	14.40 (0.90)	15.06 (1.30)	14.73 (1.10)	103.88
15,000	16.28 (1.23)	15.43 (1.07)	15.86 (1.15)	111.85
18,000	()	16.50 (2.10)	16.50 (2.10)	116.36
21,000	.....	.....	.....	.....
18,000	.....	.....	.....	.....
15,000	()	15.98 (1.38)	15.98 (1.38)	112.69
12,000	16.70 (1.28)	15.88 (1.20)	16.29 (1.24)	114.88
6,000	16.00 (0.80)	15.10 (1.10)	15.55 (0.95)	109.66
0,000	15.10 (0.72)	15.40 (1.10)	15.25 (0.91)	107.55

TABLE 40.

Changes of Pressures and Visual Simple Reaction Time.

Subject *W.*

Feet	I	II	Av.	%
0,000	16.65 (0.67)	17.13 (1.23)	16.89 (0.95)	100.00
6,000	17.23 (1.17)	17.11 (1.33)	17.17 (1.25)	101.61
12,000	17.89 (0.95)	16.80 (0.64)	17.35 (0.75)	102.72
15,000	17.98 (1.12)	18.03 (1.27)	18.01 (1.20)	106.63
18,000	18.85 (1.37)	18.30 (0.74)	18.58 (1.06)	110.01
21,000	()	21.35 (1.85)	21.35 (1.85)	126.41
18,000	()	20.70 (1.49)	20.70 (1.49)	111.58
15,000	19.50 (1.20)	19.63 (1.47)	19.57 (1.34)	115.87
12,000	17.65 (1.49)	16.95 (2.15)	17.30 (1.82)	102.43
6,000	16.50 (0.92)	18.00 (1.30)	17.25 (1.11)	102.13
0,000	17.33 (0.93)	16.76 (1.04)	17.05 (0.99)	100.95

Subject *M.*

Feet	I	II	Av.	%
0,000	18.35 (0.77)	17.78 (0.76)	18.07 (0.77)	100.00
6,000	18.85 (1.57)	18.01 (0.65)	18.43 (1.11)	101.99
12,000	19.00 (0.90)	19.20 (0.80)	19.10 (0.85)	105.70
15,000	19.31 (0.60)	19.73 (1.07)	19.52 (0.84)	108.02
18,000	20.01 (1.35)	19.90 (1.34)	19.96 (1.35)	110.46
21,000	21.70 (1.40)	19.83 (0.92)	20.24 (1.16)	112.01
18,000	21.75 (1.54)	18.39 (1.15)	20.07 (1.35)	111.07
15,000	21.05 (0.79)	19.00 (1.50)	20.03 (1.15)	110.85
12,000	19.10 (1.60)	18.48 (0.72)	18.79 (1.16)	103.98
6,000	19.35 (0.73)	18.50 (1.00)	18.93 (0.87)	104.76
0,000	18.55 (0.98)	18.55 (0.95)	18.55 (0.97)	102.65

TABLE 40. (Continued)

Changes of Pressures and Visual Simple Reaction Time.

Subject *T.*

Feet	I	II	Av.	%
0,000	17.45 (0.95)	17.51 (0.85)	17.48 (0.90)	100.00
6,000	17.71 (0.71)	18.34 (0.44)	18.03 (0.58)	103.15
12,000	18.05 (0.89)	18.13 (1.43)	18.09 (1.16)	103.49
15,000	18.46 (0.44)	19.16 (1.48)	18.78 (0.96)	107.44
18,000	19.41 (0.77)	20.48 (1.22)	19.95 (1.00)	114.13
21,000	21.45 (1.05)	21.98 (1.22)	21.72 (1.14)	124.26
18,000	21.55 (1.77)	20.95 (1.21)	21.25 (1.49)	121.00
15,000	20.73 (1.15)	20.05 (1.07)	20.39 (1.11)	116.65
12,000	20.62 (1.20)	19.88 (1.06)	20.08 (1.13)	114.87
6,000	19.41 (0.81)	19.11 (1.25)	19.26 (1.03)	110.18
0,000	18.20 (1.80)	18.26 (1.12)	18.23 (1.46)	104.29

Subject *H.*

Feet	I	II	Av.	%
0,000	18.36 (0.90)	18.07 (0.75)	18.22 (0.83)	100.00
6,000	19.33 (0.65)	19.80 (1.54)	19.57 (1.10)	107.41
12,000	19.60 (1.18)	20.21 (1.09)	19.91 (1.14)	109.28
15,000	20.75 (2.09)	20.10 (1.14)	20.43 (1.62)	112.13
18,000	()	22.35 (1.91)	22.35 (1.91)	122.67
21,000	.....	.....	.....	.....
18,000	.....	.....	.....	.....
15,000	()	22.45 (1.45)	22.45 (1.45)	123.22
12,000	19.80 (1.18)	20.40 (1.20)	20.10 (1.19)	110.32
6,000	20.98 (1.22)	19.95 (0.85)	20.47 (1.04)	112.35
0,000	18.45 (1.55)	19.85 (0.85)	19.15 (1.20)	105.10

TABLE 41.

Changes of Pressures and Choice Reaction Time,
(The small sized digits by the time records are mistakes.)

Subject *W.*

Feet	I	II	Av.	%
0,000	18.10 (2.42)	16.30 (1.52)	17.07 (1.97)	100.00
6,000	18.40 (2.48)	16.50 (1.20)	17.23 (1.84)	100.94
12,000	18.50 (1.64)	17.70 ¹ (2.94)	18.10 (2.29)	106.03
15,000	20.40 (2.32)	18.00 ¹ (1.40)	19.20 (1.86)	112.48
18,000	21.10 (2.32)	19.70 ¹ (3.52)	20.40 (2.92)	118.45
21,000	()	35.00 ² (7.50)	35.00 (7.50)	205.04
18,000	()	19.40 (3.68)	19.40 (3.68)	113.65
15,000	20.70 ¹ (3.16)	18.30 (1.62)	19.50 (2.39)	114.24
12,000	18.60 (1.32)	17.60 (1.02)	18.10 (1.17)	106.03
6,000	18.00 (3.20)	16.70 (2.84)	17.35 (3.02)	101.64
0,000	17.30 (1.68)	17.00 (1.60)	17.15 (1.64)	100.47

Subject *M.*

Feet	I	II	Av.	%
0,000	15.40 (1.12)	15.26 (0.92)	15.33 (1.02)	100.00
6,000	15.44 (1.16)	15.60 (0.52)	15.52 (0.84)	101.25
12,000	16.16 (1.08)	19.00 (3.00)	17.58 (2.04)	114.68
15,000	17.00 (3.40)	18.40 (3.04)	17.70 (3.22)	115.46
18,000	19.22 (2.82)	20.00 (2.40)	19.61 (2.61)	127.92
21,000	23.70 ² (5.92)	20.30 ¹ (2.88)	22.00 (4.40)	143.51
18,000	20.01 (1.52)	18.40 (2.72)	19.21 (2.12)	125.31
15,000	20.70 ¹ (2.56)	18.90 (1.88)	19.80 (2.22)	129.16
12,000	18.20 (1.36)	17.40 (2.04)	17.80 (1.70)	116.11
6,000	15.40 (0.92)	16.10 (0.92)	15.75 (0.92)	102.74
0,000	15.60 (1.60)	15.80 (1.12)	15.70 (1.36)	102.41

TABLE 41. (Continued)

Changes of Pressures and Choice Reaction Time.
(The small sized digits by the time records are mistakes.)

Subject *T*.

Feet	I	II	Av.	%
0,000	19.60 (1.08)	18.20 (1.82)	18.90 (1.45)	100.00
6,000	19.10 (2.56)	20.70 (1.16)	19.90 (1.86)	105.29
12,000	21.30 (2.56)	21.90 (2.48)	21.60 (2.52)	114.29
15,000	22.10 (4.56)	21.96 (2.44)	22.30 (3.50)	117.99
18,000	23.90 (3.56)	21.72 (3.10)	22.81 (3.33)	120.69
21,000	24.80 ¹ (4.56)	29.40 ¹ (6.88)	27.10 (5.72)	143.39
18,000	25.60 (2.48)	21.00 (1.90)	23.30 (2.19)	123.28
15,000	23.40 ¹ (3.08)	22.60 (3.12)	23.00 (3.10)	121.69
12,000	21.50 (1.20)	22.90 (2.88)	22.20 (2.04)	117.46
6,000	21.00 (3.20)	22.60 (2.16)	21.80 (2.18)	115.34
0,000	20.60 (1.92)	20.62 (0.98)	20.61 (1.45)	109.05

Subject *H*.

Feet	I	II	Av.	%
0,000	15.70 (1.92)	15.40 (0.72)	15.55 (1.32)	100.00
6,000	19.10 (1.72)	16.60 (2.36)	17.85 (2.04)	114.79
12,000	23.80 ² (2.64)	17.70 (2.04)	20.75 (2.34)	133.44
15,000	22.40 ² (2.28)	18.90 ¹ (4.08)	20.65 (3.18)	132.89
18,000	()	24.10 ¹ (4.88)	24.10 (4.88)	154.98
21,000	.....	.....	.....	.....
18,000	.....	.....	.....	.....
15,000	()	22.10 ¹ (3.92)	22.10 (3.92)	142.12
12,000	18.76 (1.48)	18.16 (2.28)	18.46 ¹ (1.88)	118.71
6,000	20.70 (2.16)	16.50 (2.40)	18.60 (2.28)	119.61
0,000	17.20 (2.32)	17.00 (2.00)	17.10 (2.16)	109.97

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抄 錄

心身能率に及ぼす低壓の影響

囑託 文學博士 田 中 寛 一

この報告はイギリスのオックスフォード大學病理學教室備付の低壓室に於て行つた實驗の結果である。

實驗は五種類で、被験者は六人である。結果の中で重要な點を列挙すれば次の通である。

- (1) 低壓實驗と酸素供給不足の實驗の結果によれば、低壓による心身能率の減退は主として低壓に伴ふ酸素供給不足の結果である。従つて一定の方法で酸素を供給すれば割合に低壓の處まで上昇しても心身能率の上に大なる影響はないであらう。
- (2) 酸素供給不足が心身能率に及ぼす影響は作業の種類により、個人により、又同一個人に於ても身體的狀態によつて異なる。最後のことは同一個人が同一低壓に於て失神することゝ然らざることのあるによつて認められる。
- (3) 作業の種類について云へば知的作業は身體的作業よりも低壓の影響を受け易く、又等しく知的作業に於ても一層複雑な作業は影響を受け易い。又熟練的作業に於ては影響が少い。
- (4) 如何なる作業でも能率が急に減退する低壓度がある。即ち能率減退の轉廻點がある。而して失神の起發が瞬間的に到來することは此の事實の一つの場合と見ることが出来る。
- (5) 能率減退の轉廻點は氣壓が428mm以下即ち海拔15,000呎以上の高度以上の處で酸素分壓は海上に於けるものの大凡50%に相當する處である。
- (6) 能率の減退は作業量に於けるよりも作業の動搖性及び錯誤の二つの方面から見た作業の性質に現はれることが著しい。
- (7) 内省に現はれた主な現象は種々の末梢器官に於ける變化、不安定の感を與へる船暈の感である。
- (8) 外部からの觀象に現れる特徴は皮膚の變色と興奮的態度とである。