

## DRINKING AIR

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Unable to remain silent, I spoke to myself, shouted some words, wastefully and aimlessly wasting a precious supply of air.  <i>Jules Verne "20,000 Leagues Under the Sea"</i>	At this point the travelers became completely intoxicated. It is unclear why the air burned their lungs and windpipe ...  <i>Jules Verne "Around the Moon"</i>	Changed not only the character, temperament, way of thinking of the inhabitants of Kikandon, but the epidemic spread to domestic animals ...  <i>Jules Verne "The Doctor Oaks Experience"</i>
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People who have been to great depths and heights, upon returning from there, often tell very strange things. We are talking about scuba divers and climbers alike subject to the strange intoxication caused, oddly enough, by the air itself.

For the first time, the French traveler and engineer Jacques-Yves Cousteau, famous for the invention of scuba gear and films shot with its help, told about this phenomenon. In his wonderful book "In the World of Silence" (Moscow, 1966), he said that scuba divers, having reached a certain depth, about 30-40 m, begin to get drunk and lose control of themselves. They are overwhelmed by hallucinations, causeless fun, a feeling of carelessness. Cousteau called this state of intoxication depth. And since scuba diving is always associated with a great risk to life, such intoxication often leads to the death of the scuba diver.

But the strangest thing is that climbers, on the contrary, already climbing to a certain height, are subject to a similar intoxication. This is how A.Yu. Axelrod in his book "Oxygen in our life": "At altitudes of 2500 - 3500 m, some people experience changes in behavior: they are elated, excessive gesticulation and talkativeness, an accelerated speech rate, unreasonable fun and laughter, a carefree, light-hearted attitude towards the environment. This phenomenon is called euphoria. To some extent, it is comparable to the condition accompanying mild alcohol intoxication. " At even higher altitudes, auditory and visual hallucinations often occur. In the mountains, such a carefree state also sometimes turns into the death of a person.

It would seem that high-altitude and deep intoxication are in no way connected: you never know there are intoxicating substances and mechanisms that cause similar symptoms - euphoria, carelessness, hallucinations. But, as it turned out, they are related by the fact that intoxication in both cases is created by simple air. It is the heady air of peaks and depths that often causes the death of their brave conquerors.

This became clear after the improvement of underwater and mountain equipment. So, intoxication with depth completely disappeared when heliox, a mixture of helium and oxygen, was used instead of compressed air in underwater work to combat decompression sickness. The height intoxication also disappeared when climbers began to put on oxygen masks on the rise. Rescue breathing apparatus and pilots who have taken off to great heights and are equally prone to high-altitude hallucinations and intoxication.

What is it that the deep and mountainous air contains that makes the mind clouded? For the depths, this has already been clarified - it's all about nitrogen. After all, it is nitrogen, which makes up 4/5 of the volume in ordinary air, that is absent in heliox: it is replaced by helium. For still unclear reasons, during immersion and a corresponding increase in the pressure of the inhaled air, and therefore nitrogen, the latter begins to have an intoxicating effect on a person. Therefore, deep intoxication is often called nitrogen poisoning.

As for high-altitude drunkenness, the reasons for it are also not entirely clear. It is believed to be related to oxygen deprivation in the brain. After all, the higher the mountains, the less air and oxygen. The nitrogen pressure will also be less, so it would seem that nitrogen poisoning has nothing to do with it. But it may turn out that the matter is not at all in the nitrogen itself, but in its compounds. Indeed, nitrogen is a very inert gas ("nitrogen" means "lifeless"), which does not react, and therefore does not affect our life. But on the other hand, its compounds play a very important role in nature.

This is especially true for gaseous nitrogen oxides. It turned out that in the body they are in second place after oxygen. Suffice it to say that it is nitric oxide NO that regulates the width of blood vessels. So, it is with him that the therapeutic effect of nitroglycerin is associated. Several gaseous nitrogen oxides are known, the main ones being NO<sub>2</sub>, NO and N<sub>2</sub>O. The latter, N<sub>2</sub>O, called nitrous oxide, is of particular interest. The fact is that it is this gas that is capable of causing intoxication, euphoria, and causeless fun, for which it is often called "laughing gas".

What if the deep intoxication is connected with it, and by no means with the nitrogen effect on the body? Could at high pressure air - this mixture of nitrogen N<sub>2</sub> and oxygen O<sub>2</sub> - stand laughing gas N<sub>2</sub>O? This seems all the more likely that deep intoxication divers themselves compared it to laughing gas intoxication. Foreexample, Cousteau says this about deep intoxication: "This intoxication is suggestive of the drunken gatherings of the twenties, when drug addicts gathered together and inhaled nitrous oxide." Another author writes: "The higher the pressure, the stronger this action is manifested, more and more resembling the action of the "laughing gas" - nitrous oxide." Fainting and drowsy conditions that occur during diving also largely resemble medical anesthesia, general anesthesia with the use of nitrous oxide.

Why didn't anyone suggest that laughing gas was the crux of the matter? It's simple: they believed that there was no nitrous oxide in the air and there was nowhere for it to come from, since nitrogen is so inert that even at increased pressure it should not react with oxygen or with other substances. It's all about the strength of the nitrogen molecule N≡N: it's too difficult to separate the N atom from it for the reaction. To do this, you need to break all three links (shown by dashes).

However, in contrast to other reactions, it is not necessary at all to remove a nitrogen atom to obtain an N<sub>2</sub>O molecule. Indeed, in the laughing gas molecule N=N=O, nitrogen atoms, as in the N≡N molecule, are bound, and it would be enough to break only one of its bonds. And perhaps even tearing it is useless, because the N<sub>2</sub>O molecule, as it were, alternately takes one of the forms N=N=O and N≡N-O. So, it turns out that nitrogen should react much more easily with oxygen than with other substances, especially at high pressure, when the equilibrium of the reaction  $2N_2 + O_2 = 2N_2O$  shifts to the right: more N<sub>2</sub>O is formed. So nitrogen is not such a "lifeless" gas. In this regard, it is time to recall the forgotten hypothesis of the mechanical engineer M.I. Volsky about the assimilation of atmospheric nitrogen by animals and humans [1].

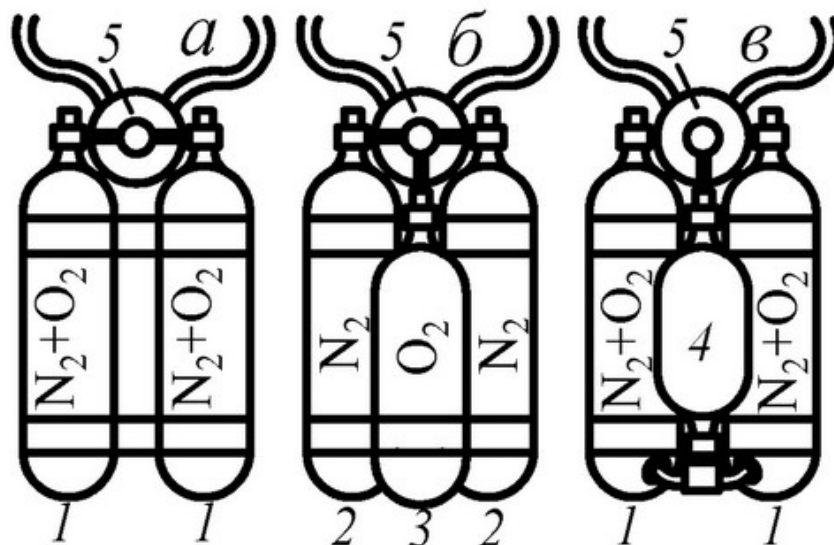
There are also facts confirming the guilt of N<sub>2</sub>O. For example, the long-standing experience of the Swiss Professor Hans Keller, who dived to a depth of 120 meters and breathed a mixture of 95% nitrogen and 5% oxygen for five minutes. At the same time, he did not develop any symptoms of deep intoxication. This confirms that it is not only nitrogen, but also oxygen: Keller was the first to point out that intoxication is created by the joint action of several gases. Indeed, the amount of nitrous oxide released in the reaction  $2N_2 + O_2 = 2N_2O$  is influenced not only by the nitrogen content, but also by the oxygen content. Although the N<sub>2</sub> pressure was slightly increased, the O<sub>2</sub> content, usually 20%, was reduced by as much as four times, which proportionally weakened the reaction.

But that's theory, but how to deal with deep intoxication in practice, if it's really about nitrous oxide? It is impossible to remove oxygen from the respiratory mixture, otherwise it will lose its meaning. And removing nitrogen, replacing it with scarce helium, is too expensive. This means that both gases must be left, however, weakening or eliminating their reaction. You can, for example, try to find some kind of inhibitor - a substance that blocks the reaction and causes the decay of N<sub>2</sub>O. But other ways are also possible. The easiest way out is to separate oxygen and nitrogen so that they are stored separately in scuba, in different cylinders and mixed only immediately before inhalation, already at operating pressure (this is how Keller's scuba was arranged). Then they simply will not have time to react: nitrous oxide will not have time to form.

In addition, in scuba cylinders, the air is pre-compressed to a huge pressure of 200 atmospheres, corresponding to a two-kilometer depth. And at such a pressure, nitrogen and oxygen should react already in the cylinder, and the initial concentration of nitrous oxide formed there should be huge. When the pressure in the cylinder reducer is reduced, a significant part of the  $N_2O$  should decompose. But the completely laughing gas will not have time to disintegrate and will fall into the lungs of a scuba diver. So, the problem is not only in the high pressure of the air inhaled at depth, but also in its even greater pressure inside the cylinders.

Not without reason, when working in a three-bolt diving suit, in the helmet of which air is supplied not from a cylinder, but from the surface, through a hose, intoxication with depth occurs only at much greater depths - about 80-90 m. There should be an opposite effect. In atmospheric air that has just been compressed on the surface, nitrogen and oxygen do not have time to form laughing gas. True, if the air in the suit stagnates, they can react already inside it. No wonder one of the effective ways to combat deep intoxication in such underwater equipment is the forced blowing of the suit with fresh air [2]. The fresh air seems to be carrying the nitrous oxide accumulated in the suit with it.

From here you can take out another simple way to reduce the degree of deep intoxication in scuba diving. It is necessary that the air from the cylinders does not enter the scuba diver's lungs immediately, but is directed before into another volume - a preliminary expansion cylinder. The pressure in it should be only slightly more than that of the air inhaled by the scuba diver. And since the air from this cylinder would not flow to the diver immediately, the nitrous oxide that got into it would have time to decompose to an equilibrium concentration for a given pressure.



Обычный (а) и "безалкогольные" акваланги: раздельный (б) и с предварительным расширением (в).  
 1- баллоны высокого давления (200 атм) с воздухом;  
 2- баллоны высокого давления с азотом  $N_2$ ;  
 3- баллон высокого давления с кислородом  $O_2$ ;  
 4- баллон предварительного расширения (5-10 атм);  
 5- лёгочный автомат с газовыми редукторами.

And yet, a Keller system scuba diving with separate storage of nitrogen and oxygen would be more efficient. In addition, according to Keller's proposal, with immersion, the proportion of oxygen in the mixture should decrease so that with depth its partial pressure does not grow as fast as the pressure of the entire mixture. On the one hand, this would eliminate the toxic effect of concentrated oxygen, and on the other hand, it would further weaken its reaction with nitrogen.

The air supply system of underwater houses and laboratories should also be changed accordingly, because, as follows from the same book by Cousteau, their inhabitants also often succumb to inexplicable fun and lose control of themselves. And although such houses are usually placed no deeper 12 m, the intoxicating effect of nitrous oxide can also manifest itself there due to its prolonged formation and long-term effects on the body.

It may be interesting for the reader to reflect on the specific technical implementation of the proposed scuba gear. This is not an easy engineering task. So, scuba diving will need new gearboxes, and not simple ones, because they will have to automatically reduce the pressure (gas coming out of the cylinders) not to the one available in the surrounding water, but to something else proportional to it. The automatic gearbox, scuba regulator, the so-called lung machine [3], is its most important and responsible part (it was the creation of such an automaton that was the main merit of J.-I. Cousteau and his companion E. Gagnan). That is why its device should be extremely simple and reliable.

But perhaps we have gone too far. It's time to look up and ask yourself about the causes of high-altitude intoxication. The situation there is completely opposite - the air pressure is not increased, but, on the contrary, is noticeably reduced. So where does nitrous come from? Oddly enough, it is at high altitude that nitrous oxide is most abundant. And the point here is no longer pressure, but radiation. In the mountains, the radiation of the sun, especially ultraviolet, is much more intense than near the surface of the Earth, since a significant part of it is absorbed by the underlying dense layers of air, including the notorious ozone. This radiation tears the air molecules into atoms, ionizes the air. And in particular, the molecules of nitrogen and oxygen are broken. As a result, at a height, their atoms easily combine, forming nitrous oxide. Apparently, it is this high-altitude laughing gas that causes intoxication with height.

Well, it remains to find out how the nitrous oxide present in the air is reflected on those who live somewhere between heights and depths, that is, on you and me. Of course, it may seem that it is not in the air at all, because almost all laughing gas that has arisen at transcendental heights disintegrates by the time it reaches the surface. But, as follows from the Great Soviet Encyclopedia (article "Atmosphere"),  $N_2O$  is still present in the air in an amount of 0.00005%: there is half a cube of  $N_2O$  per cubic meter of air. This is not so little: in terms of content in the air, nitrous oxide is in 9th place, sharing it with hydrogen.

But can this tiny amount of laughing gas somehow affect us? If yes, then such an effect would become more noticeable with a slight increase in air pressure. Many, probably, paid attention to a strange light condition that occurs with fast, intense breathing or when inflating a balloon. At the same time, the air pressure in the lungs rises and the concentration of nitrous oxide in the lungs, and hence in the blood, should increase proportionally. Maybe it was she who caused this state reminiscent of intoxication?

By the way, rapid breathing without physical activity is also characteristic of laughter. Man, and even animals, produce a series of frequent and sharp, as if convulsive, respiratory movements during laughter. Scientists cannot specify what their meaning is. Who knows, maybe when we want to laugh, we reflexively take such quick breaths in and out, just in time to saturate the blood with laughing gas present in the air. In this case, it is nitrous oxide that should create laughter and a light, pleasant state caused by it.

Laughter, as psychologists have found, is a kind of protective reaction of the body that occurs in response to a violation of logic, to an overload of the brain. Laughter gives a nervous discharge, relieves stress from the brain, frees it from "looping", "freezing", in short, it does not let us go crazy (in life and films, computers and robots break down precisely from paradoxes, logical inconsistencies). To protect the brain, the body could simply throw into the blood the hormones of joy, fun, the so-called endorphins, creating mild intoxication. But the body should strive to save them, using them only at the very first, "flashing" stage of laughter, and then create intoxication and fun with the free laughing gas of the air. It turns out that a person cannot live without nitrogen, otherwise full-fledged laughter is impossible, and there is a threat to reason. In this sense, our spacecraft with an air atmosphere were preferable to the American ones, in which the astronauts breathed pure oxygen at reduced pressure.

Sobbing, shaking of the chest when crying in many ways resembles laughter. So here, perhaps, a defense mechanism is triggered, saturating the blood with laughing gas and protecting the brain from an overload of grief. No wonder they say: "Cry - it will be easier."

Sometimes the concentration of laughing gas in the air can grow so much that even without increased breathing it will cause laughter. Perhaps it was precisely this increase that caused the sometimes occurring epidemics of mass hysteria, insane, unreasonable fun of huge masses of people (descriptions of such cases can be found in F.Yu. Siegel's book "The Sun is Guilty"). Moreover, as shown by A.L. Chizhevsky, most of these psychic epidemics occurred during the years of increased solar activity. Because of it, the concentration of  $N_2O$  in the air should have increased: after all, the effect of solar radiation on the atmosphere increased several times, and air ionization and the formation of  $N_2O$  became possible even at low altitudes. By the way, most often such epidemics of mass laughter and psychosis occur in the mountains, where, as we know, the concentration of  $N_2O$  is already high. In this sense, the city of Mexico City, located at an altitude of about 2200 m, is very interesting. UFOs are seen there more often than anywhere else. But, perhaps, this should be explained by mass hallucinations from a temporarily increased concentration of  $N_2O$ , very close to the threshold at such a height.

Is it not for this reason that the thunderstorm air is intoxicating? Chizhevsky's chandeliers should give partly the same effect - air ionization facilitates the formation of nitrous oxide. Is this not how the yogis enter the state of nirvana, who attach the main importance to breathing and therefore are surely able to saturate the blood with nitrous oxide, which is so rich in the air of the mountains, where yogis often live? Even in the mechanism of sleep,  $N_2O$  may play a role. Indeed, immediately at the moment of falling asleep, a person begins to breathe deeper, more intensively, although at rest it would seem that breathing should, on the contrary, weaken. Maybe this is how we saturate the blood with nitrous oxide, which introduces us into a kind of anesthetic sleep, followed by natural sleep? Isn't that why people sleep on orbital stations much less than on Earth? After all, the air pressure is usually low there, which means that the concentration of  $N_2O$  is low. On the other hand, when the station is penetrated by powerful streams of cosmic rays, ionization there, on the contrary, should increase the concentration of  $N_2O$ , which is likely to explain the hallucinations in orbit.

But we are, perhaps, overly carried away. It would not hurt, therefore, to find out the opinion of authoritative scientists about nitrogen intoxication and its explanation. For this purpose, the article was sent to A.N. Vyotosh, a specialist in the effect of nitrogen on the human body. However, the author did not receive an answer. Silence should obviously be regarded as a sign that there are no convincing arguments either for or against the hypotheses presented in the article. Indeed, the problem of deep and high-altitude intoxication, the mechanisms of action of nitrogen and  $N_2O$  on the human body, the nature of laughter are still very poorly studied. Therefore, the conclusions of the article should be considered only as hypotheses. In particular, the creation of the "non-alcoholic" scuba tanks proposed here is possible only after the role of  $N_2O$  in creating deep intoxication has been experimentally clarified. But the fact that simple air is capable of intoxicating a person is no longer in doubt. And the expressions "the heady air of freedom, thunderstorms, peaks" acquire by no means a figurative meaning.

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#### Literature:

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- 2 . Karpichev V.G. - M.: Thought, 1984.
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