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On the Issue of Cleaning Up the Air in Passenger Coaches (1891–1892)


Желѣзнодорожное Дѣло
ЖУРНАЛЪ
Годъ XI.

News from the archives
This material briefly reproduces the main content of the article by Alexander Kritsky in the «Railway Business» journal in 1891 and 1892. The very fact of a multi-issue and very voluminous publication shows how much attention was paid at one time to the issue of air purity in railway passenger cars.
The original punctuation, vocabulary and abbreviations adopted at that time are preserved in the text as much as possible.

Keywords: *transport, history of transport, railways, passenger coaches, ecology.*

«Judgments take on the character of necessity, when they endure a double critical process statement of reasons and agreement by experience».
H. Lewis

We briefly examined in the pages of this journal[1] the changes to which the air in passenger cars can be subjected, and as a result of which it becomes more or less harmful to the passengers in it.

The next task that seems to be necessary to solve is, first, to determine, as far as possible, strictly what impurities in the car air and in what percentages should be recognized as harmful to breathing of passengers, both in themselves and because of the influence that they affect the change in the normal relations of the elements of atmospheric air. Once this problem has been clarified, it would be necessary to carry out a qualitative and quantitative analysis of this car air in order to draw up a conclusion about its quality. A number of such analyses and subsequent generalisations could lead to simplification and facilitation of the issue of determining the air quality in passenger cars.

[1] See «*Zheleznodorozhnoe Delo*» *[Railway Business],* 1891, No. 39–40 and 42–43. – *Ed. note.*

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The text of the archived article originally written in Russian is published in the first part of the issue.
Текст архивной статьи на русском языке публикуется в первой части данного выпуска.

The next task after this will be to find means and ways to bring the spoiled and designated for breathing air into such a state in which it could be recognised as harmless!..

These are the immediate tasks that should be pursued when solving the problem of improving the air in passenger cars; obviously, they differ significantly from those relatively broad tasks that can and should be presented in solving such problems as the question of improving the air in schools, children's, hospitals, etc. In the latter case, the tasks are reduced not only to preservation and maintaining the constitutional properties of the body, but also to a correspondingly normal course of its development, as far as it depends on the quality of the indoor air.

For a solution to the question of the purity of the air in a given room, we are used to turning to our sense of smell, that is, we are used to judging the degree of purity of the air by its smell; obviously, this method is quite subjective, but it will not be necessary to turn to it more than once. Prof. Pettenkofer, who devoted a lot of time to studying the issue of improving the air in residential premises, recognizing assessment of air by smell as quite correct, believed that the most rational and, moreover, quite objective solution to the problem of air quality could be obtained if we had at our disposal a method of concentrating and direct measurement of odorous substances contained in the air. Later observations and practical data showed that the smell cannot serve as a sure means for assessing the air in enclosed spaces, as a result of which it should be handled with extreme caution. The bad odor, according to Professor Naegeli, which accompanies decomposition, only indicates that the embryonic forms are still developing under the influence of humid air; the most dangerous moment comes when the humidity decreases and germinal forms, drying up, spread in the air in the form of dust. The smell stops, but the air becomes extremely spoiled…

Having familiarised ourselves somewhat with the work on determining the quality of air in passenger cars depending on the content of carbon dioxide in it, we now turn to assessment of such definitions in general.

There are no sources of carbon dioxide in the cars, except for the current excretions of the body, for example: the processes of decomposition of organic compounds in the air and development of microorganisms (some scientists believe that carbon dioxide can serve as a measure of these processes[2]), tobacco smoking, artificial lighting and heating of cars; to this should also be added the residual carbon dioxide contained in the air and enveloping dust particles and tissue fibers. It is known that dust particles do not diffuse in the same way as air in general and carbon dioxide in particular, walls and even cracks filter them, they settle and can gradually be deposited in layers. This circumstance was especially sharply revealed during air analyzes by Dr. Tolvinsky in tents, where, despite the large pores in the canvas (pierced even by rain), the air was just as bad as in stone rooms. I draw attention to these sources of carbon dioxide because their existence in the car is exactly the circumstance that Pettenkofer emphasizes so much when recommending his scale, and which one has to reckon with in one way or another.

All of the above and, in general, the instability of the Pettenkofer method leads us to the conviction that the judgment about air quality, based on the measurement of carbon dioxide in it, is extremely unreliable and can lead to serious errors.

As for the direct effect of carbon dioxide on the body, most scientists agree that the content of carbon dioxide, usually found in indoor air, is not harmful and, therefore, carbon dioxide cannot be considered as a poisonous admixture to car air. The accumulation of carbon dioxide up to 6–7 % is often tolerated without any complaints about such air (Leblanc, Smith and others). Dr. Albitsky proved with his experiments that harm and deep disorders in the body begin with a relatively high percentage of carbon dioxide in the air, namely between 10 % and 20 %, and 30 % of carbon dioxide produces positive asphyxiation.

Now the question naturally arises, which of the car air impurities considered by us are the most harmful and whether there is any other way to determine the quality of the car air.

We have already said that in the atmospheric air there is constantly a certain amount of free ammonia, which fluctuates within very significant

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[2] In view of favourable conditions that take place in the cars for the processes of decay and development of microorganisms, namely high humidity and high temperature (about 20°C), serious attention should be paid to this source; here, by the way, it should be noted that with the decomposition of organic substances, the release of carbon dioxide does not always go in parallel (Dobroslavin) and that the assumption given in brackets requires confirmation by experiments.

limits; in the air of the car, this ammonia content increases quite significantly, partly due to the addition of protein ammonia to it, which is released during the processes of decomposition of organic dust particles that are carried in the air of the car, as well as settled on walls, furniture, etc., or have not yet been separated from the surface of the skin and mucous membranes of the body, partly due to the addition of ammonia, which is a product of the decomposition of urine in retirades.

The question of what amount of ammonia in the air of the car can be allowed as not harmful to passengers still needs to be resolved. It is known that the amount of ammonia in poorly maintained residential premises reaches up to 1 % (Edwars); of course, such a content of this gas in the air of the car, despite the great adaptability of the body, cannot pass without a trace.

Determining the excess of ammonia, above atmospheric, in the air of cars and living quarters in general, according to some scientists, can serve as a measure of air quality and the degree of its harmfulness; from this point of view, a detailed study of ammonia, as an impurity in car air, is of undoubted interest, especially since there is strong evidence in favour of the advantage of ammonia as a measure of air purity, compared with carbon dioxide.

At present, organic dust, which serves as a soil for development of microorganisms and carries in its composition the germinal forms of the latter, is recognized by almost everyone as the main factor in air damage. The constant existence in the air of such germs and microorganisms capable of causing the processes of fermentation and putrefaction was confirmed by the excellent experiments of Prof. Pasteur. This dust is mainly attributed to the odourousness of car air and the poisonous effect of the latter on the body.

From all of the above, we see to what extent it is important to be able to subject the dust of the car to research. This study would best allow us to judge the quality of the air in the car.

In addition to organic dust, we must turn our attention to car dust in general. We know that dust particles contribute to contamination of the surface of the mucous membranes of the larynx, large and small respiratory tracts, etc., sticking to them and thus adversely affecting their functioning, often producing an inflammatory state of the membranes and even ulcers – not I'm talking about the irritating effect that dust has on the general nervous system. Anyone who has had to ride in cars or spend some time in the dusty rooms of archives, libraries, museums, etc., is well aware of the fact that the pharynx dries up accompanied by thirst, the fact of drying of the nasal cavity, the appearance of a runny nose, etc.

As for the methods for determining the quality of car air, based on the presence of organic dust particles in it, similar to protein substances, then naturally, we must dwell on methods that are more applicable and more reliable under the existing situation in the cars.

A causal relationship has long been noticed between the existence of ozone in the air and the degree of purity of the latter, i.e., the degree of content in it of extraneous organic residues capable of being oxidized. According to Ebermeyer's experiments, even in a deliberately clean residential area, it was not possible to detect the presence of ozone; only with the doors and windows wide open for the free entry of the wind did a weak *ozonoscopic* reaction appear, which disappeared as soon as the access for the free entry of the wind was stopped…

…These and many other experiments convince us of the validity of the previously indicated causal relationship between disappearance of ozone and purification of air from organic residues; and to these latter, as already mentioned above, harmfulness of indoor air is mainly attributed.

All of the above gives us the right to use ozonometric studies of it to determine the quality of car air, in extreme cases, with much less accuracy, ozonometric study of air samples taken at various points in the car. These studies can be carried out by gradually introducing a certain amount of ozone into the air of the car, developed by any means, electrical, chemical or even mechanical, and observing the change in color of ozonometric (starch iodine) papers located along the car[3].

The determination of carbon monoxide in cars depending on heating, as well as tobacco smoking, is of undoubted interest in view of the toxic effect on the body that even a relatively small presence of this gas in cars has. The experiments of Grean, Gryaznov and others showed that when smoking tobacco, a significant amount of carbon monoxide

[3] The method of preparing ozonometric paper is described in detail in the Dobroslavin hygiene course, 2nd ed., Part I.

develops, and therefore this issue deserves serious research. Naturally, we should be interested in the issue of improving the air in cars mainly with those impurities, the harmful influence of which we suspect; here it is necessary to include hydrogen sulphide gas, some organic acids, etc.; the presence of these latter in cars, in all likelihood, does not exceed very small values, and therefore the main role in air pollution will remain on the side of dust.

Now let's move on to considering the issue of air humidity in the cars.

The artificial conditions in which a person is placed in the closed atmosphere of cars change to a greater or lesser extent the functions of his organism and cause them to be coordinated with each other. The vast majority of *coordinations*, owing to their complexity and variety, cannot be discovered by us; however, when studying the influence of artificially created conditions on the organism, one should always keep in mind the existence of changes and coordination of various functions of the organism caused by the combination of these conditions. From this point of view, the hygrometric state of the air in residential premises is of incomparably greater interest than it seems at first glance at the matter.

Despite the apparent simplicity of the question under consideration, it is still in the group of little studied and from time to time arouses a complete disagreement in opinion, probably due to its insufficiently correct formulation.

From the graphic table of humidity, placed in No. 39–40 «*Zheleznodorozhnoe delo*» of 1891, one can see how significant fluctuations are subjected to both relative and absolute humidity of atmospheric air; for us, obviously, the question of relative humidity is more important, since its percentage expression gives an idea of how much more a given air can take moisture away from existing wet objects[4]. It would be extremely hasty, based on such given average values of atmospheric air humidity at some or even many points, to try to establish humidity standards for enclosed spaces in general and cars in particular. The influence of a given hygrometric state of atmospheric air on the body cannot in any way be identical with the influence of the same hygrometric state of enclosed air, as will be clarified below – rather, a significant difference should be expected.

The conditions for staying in cars, speaking in general, are very close to each other in different even very remote points of the state, especially during those periods of time when we are under the most prolonged and greatest influence of closed air, i.e., during those periods that are of the greatest interest; meanwhile, choosing the norms of humidity in car air, we are talking about the average annual values of atmospheric humidity, about the fact that nature itself indicates to us certain limits, about the habit of certain fluctuations in humidity that exist in a certain area, etc., and so on. Even conclusions about harm or harmlessness of one or another vapor content in closed air are made on the basis of considerations that such and such humidity occurs in nature in healthy areas, while these limits are very wide, for example: 13 % (Yalta, Sevastopol, Tashkent), 96–90 % and above (Moscow, Simferopol and others). The groundlessness of such considerations is too obvious to be elaborated upon.

As a result of such a formulation of the question, no humidity standards have yet been developed with which it would be possible to compare this hygrometric state of car air. Everyone who begins to speak or write about this subject, with equal right, proposes his own norms, and just like others, without sufficient reason.

Professor August considers humidity to be normal between 45 % and 50 %; in Boston, a commission of specialists determined that humidity should be considered normal from 60 % to 70 %; Professor Chaumont gives values for England from 70 % to 80 %; Dr. Taratkevich for our climate, in his work on ventilation of cars, considers it necessary to establish norms of 40–60 % on the ground that the humidity limits of America and England cannot be applied to our continental climate, where outside air is usually with a low percentage of humidity (?).

Here is what E. Lenz says about the choice of limits in the content of water vapor for residential premises: below 40 % humidity is of course insufficient; by inhaling such dry air the lungs would be too dry (?)[5]; on the contrary, the

[4] The degree of humidity of a given air, as it turned out recently, is most clearly characterized by the amount of under-humidification (Sattigungsdeficit), which expresses the amount of vapor (in grams per cubic meter) that this air can still absorb before it is saturated, or, approximately the difference between the pressure of the vapors saturating the given air and the pressure of the vapors contained in it in reality.

[5] In Petersburg, which is distinguished by its dampness, according to prof. Flavitsky, the best clear days of the year with fine weather and pleasant healthy air are accompanied by a low percentage of humidity below 50 %, even at 30–24 % and below.

No. of gen. table (work. of Taratkevich)	Time of observations	Number of occup. seats absol. and %	%, Humidity			°C, Temperature			Number of observations	Note
			Average	max	min	Average	max	min		
10	11/III	38/55	63,6	77	60	19,3	20,0	17,0	3	Ventil. open
11	–	30/45	63,6	72	64	21,9	24,0	19,8	3	
12	20/I	42/60	93,5	98	88	16,7	17,0	16,4	2	
13	–	45/65	77,0	79	75	19,9	24,0	16,2	2	
14	23/I	58/84	85,0	92	79	20,1	22,0	18,4	2	
16	16/III	70/100	74,5	79	67	22,9	24,6	18,4	4	
17	–	–	75,0	79	71	23,0	25,4	20,4	4	
18	–	62/90	83,0	85	81	17,9	19,8	16,0	2	
19	–	70/100	75,5	78	73	21,4	23,9	19,8	2	
20	–	–	74,0	77	71	23,0	24,6	21,6	2	
21	–	68/97	78,0	78	78	20,0	20,0	20,0	1	
22	22/III	47/68	73,6	79	66	19,8	22,0	17,4	3	
24	–	50/72	70,0	72	66	21,2	21,2	21,0	3	
25	–	–	82,0	86	74	19,6	22,4	18,0	3	
26	–	58/84	77,0	79	74	20,8	21,6	20,0	3	
29	30/III	68/97	78,0	81	75	19,0	20,0	18,0	2	
30	–	54/78	79.5	83	76	18,4	19,2	17,6	2	
31	–	57/83	81,0	87	78	18,9	20,9	18,0	3	
32	–	57/72	78,0	80	77	21,3	22,0	20,2	3	
33	–	50/72	78.0	73	78	16,0	16,0	16,0	1	
34	4/IV	53/94	74,6	76	73	20,9	23,2	19,0	3	
36	–	70/100	67,0	75	62	19,5	20,0	18,4	3	
37	–	–	77,3	80	75	19,1	20,0	18,4	3	
Average of all			76,46	80,4	73,09	20,01	21,41	19,48	59	

humidity of the air can reach 100 % without any particular trouble for the breathers and without harm to health, but with this perfect saturation, the slightest drop in temperature produces a precipitate of the water in the vapor, from which all objects that receive moisture become damp; so we will take the upper limit of humidity below 100 %, about 80 %.

If the internal temperature is 18°C, then at 80 % humidity this air can cool down to 14,5°C, producing a precipitation of water vapor; at 40 %, it can cool from 18°C to 4,3°C without vapor deposition.

What is the degree of humidity actually encountered in passenger cars?

Dr. Taratkevich made a number of observations on humidity in cars of various classes; the largest number has been determined: it was made in third-class cars, which is why I give here humidity readings in connection with temperature for third-class cars.

The highest observed humidity = 98 % at 17°C, the lowest 47 % at 15,6°C., the latter in an old class II car. Using these data, one can only come to the conclusion that humidity in passenger cars is extremely high even in the cold season (most of the observations were made in January and March), with a slight decrease in air temperature, vapor is already deposited on walls, windows, etc.; along with this, development of organic dust decomposition processes is more energetic, as a result of which the car air becomes odorous and extremely unpleasant.

After briefly reviewing the hygrometric state of air in cars, it remains for us to consider some considerations regarding the choice of humidity standards. This question, which plays a very important role, I believe, could be solved only depending on the thermal economy of the body, that is, on the desire of our body to maintain thermal equilibrium, despite the difference in external conditions.

We know that, due to various life processes, a huge amount of heat is released in our body, according to Pettenkofer, more than 3 million units per day; this heat could be heated from 0°C to 100°C 30 cubic decimeters of water; under certain circumstances, the amount of heat released can increase or decrease by up to 50 %; at the same time, in order to preserve health, it is necessary that the heat of the body does not change significantly, i.e., that the heat input inside the organism and the expenditure on its periphery are in some balance.

How is the body's thermal equilibrium maintained?

In this case, we are only interested in the question of the expenditure of the excess developed heat by the body.

The expenditure of such a huge amount of heat by the body occurs in three ways: a) by radiation; b) by transmission through other bodies; and c) by evaporation. There is a constant coordination between these three paths; the increased expenditure of heat in one way is accomplished at the expense of the other two, and vice versa. The expenditure of heat by radiation and conduction under normal conditions is constant to some extent; in evaporation, one should see the most important means at the disposal of the organism for restoring the disturbed balance in its thermal economy.

We have already seen how much water vapor is released from the body. During the experiments of Voight and Pettenkofer with the famous Munich respirator, it was found that by pulmonary and skin respiration, water evaporates in 24 hours from 900 to 2000 grams or more, as a result of which 504,000–1,120,000 units of heat are taken from the body (One gram of water for circulation in steam consumes 560 units of heat released by the body).

The following table, compiled according to Pettenkofer, gives an idea of the striking difference in quantitative effects that is achieved by evaporation during pulmonary respiration of an adult, depending on temperature and humidity.

Temperature, °C	Humidity, in %	The amount of heat released per day in calories	Difference
0°	0 %	293 040 cal.	–
0°	50 %	279 090 cal.	13 050
0°	100 %	265 050 cal.	14 040
30°	0 %	274 050 cal.	–
30°	50 %	189 720 cal.	84 930
30°	100 %	105 390 cal.	84 330

The human body, however, has a huge degree of adaptability, but it should be remembered that the intensity of functioning of any organs or their prolonged weakening could not pass without leaving a trace in the sense of influencing the general condition of the body.

With dry and warm air, functioning of the vasomotor nerves increases and, at the same time, evaporation; enhanced functioning produces known morbid phenomena in the body, the degree of which is in direct proportion to intensity and duration of functioning.

In warm and humid air, maintenance of thermal equilibrium in the body is extremely difficult since the above ways of expending heat are already paralyzed to a greater or lesser extent. Depending on the degree of humidity of the closed air, the amount of moisture released by the body is significantly reduced. This amount must be considered as a function of humidity of the ambient air, which is unfortunately not known; it is easy to see that there should be an inverse relationship between these two quantities (E. Lenz). The excess of accumulating heat in warm and humid air and increased functioning of the organs, striving to restore balance, are reflected in a certain painful way on the body.

Let us now consider the real conditions in which the passengers of the cars are in relation to maintenance and regulation of the thermal economy of the body.

The radiation of the body is completely eliminated in the tightness of the car, since the body is surrounded by equally warm bodies, i.e., inflow and outflow are mutually covered, but in places close to walls and windows, extremely harmful non-equilateral radiation occurs; thermal conductivity decreases to extremely small sizes, since the air of the car, having very low mobility and reduced, due to relatively high humidity, thermal transparency, soon acquires a temperature close to the temperature of the surrounding warmer environment. And so the main expenditure of heat falls on evaporation of moisture from the skin and membranes. At an elevated temperature and a certain, still insufficiently elucidated degree of humidity in the car air, the pores of the skin open up extremely, a need is felt for an increased air flow in order to increase the transfer of accumulated heat; meanwhile, the air of the car seems to us completely motionless[6], the open pores are polluted with car dust, in which the work of decomposition begins, there is a lack of air, thirst, that is, the need to cool the shells, and even excessive dryness; the last circumstance (deception of feeling) was observed more than once in cramped living quarters with warm and humid air.

Usually, supporters of more humid air, as well as supporters of drier air in living quarters, defend their one-sided opinion on the influence of the climate of various localities on human health. This grateful ground of defense requires, however, the utmost discretion, owing to the complexity of the conditions involved[7].

Refraining from considering this side of the issue, I will proceed to clarify the role that a change in the proportions of oxygen in the inhaled air can play in relation to the harmless stay of passengers in the car.

Above[8], we pointed out the fact that the volumetric oxygen content in atmospheric air is very close to constant, its fluctuation amplitudes are in very small limits of 0,04–0,13 %; meanwhile, in the air containing many organic, easily oxidized substances, the researchers found constantly less oxygen.

A rich series of data obtained from Smith's analyses in Manchester and many other places in Great Britain indicate a constancy in reduction of oxygen under certain conditions. If we pay attention to how much air passes through our lungs, then a relatively small deficiency in oxygen will give a noticeable decrease in total.

The decrease in oxygen in the air occurs due to a change in barometric pressure, due to displacement of part of it by water vapor, various gases, solid suspended dust particles, etc. In view of the lack of direct experiments, there are no data to judge this.

Since, as oxygen decreases in the air content, various harmful impurities can take its place, the circumstance of reducing oxygen in the car air should attract serious attention. This last may indicate the existence in the car air of certain unfavorable or even harmful conditions that modify the normal composition of the air. Unfortunately, analysis of the oxygen content in the air are extremely difficult, and are available only to a well-equipped laboratory, so we have to abandon these determinations in the car air.

All of the above shows that the decrease in oxygen in the car air can by no means be ignored. The circumstances of this decrease in the oxygen content clearly indicate the fallacy of the opinion that the decrease in oxygen existing in living quarters is so small that it can be generally neglected, on the grounds that an incomparably greater decrease in this component of air occurs in nature and we still feel good.

Leaving aside the enormous physiological influence that a change in atmospheric pressure[9] has on our organism, I will say a few words about the hygienic significance of light.

This question is relatively young to be able to come to an unconditional solution to it. From the experiments of Speck, Fubini, Ronk and others, it turned out that light increases the release of carbon dioxide. To what extent this circumstance affects, in the sense of counteracting the accumulation of an excessive amount of carbon dioxide in the body, there is not enough data to indicate. Davies and Blunt showed that strong illumination adversely affects development of lower life forms, bacteria; on this basis, light is ranked among the most powerful disinfectants. If the dwelling is abundantly lit by sunlight, then the processes of decay of organic substances, smoldering and decay are significantly reduced. The large number of windows in cars is, of course, an enormous advantage in this respect compared with living quarters. Not the last role is played by the sun's rays in the sense that by producing local heating of objects or air, they contribute to the imbalance of the latter and cause air currents, which in themselves can inhibit development of lower organisms…

Let us proceed to consideration and evaluation of those measures that are practiced to one degree or another by the railways in the form of improving the air of passenger cars.

It is obvious that in order to achieve more satisfactory results on the way to this goal, it is necessary to combine arrangement of cars

[6] At a speed of less than $^1/_2$ meter per second, we feel surrounded by absolutely calm air, only at a speed of 1 meter do we begin to feel a slight movement of air.

[7] F. Klöden. Phys. geogr. Healing and harmful climates.

[8] See No. 41–42 «*Zheleznodorozhnoe delo*» of 1891. – *Ed.*

[9] Flammarion considers the pressure of about 764 mm Hg to be the most favorable for the general condition of the body.

themselves with their maintenance during operation. Much has already been done in this regard, but much remains to be done to achieve a possible improvement in the air intended for breathing passengers.

The measures taken by our railways are directed chiefly to improving the design of cars in general, to improving their heating, lighting and ventilation systems; for this, much less attention is paid to cleaning the cars from dust and dirt, as well as cleaning and disinfecting the retractors during operation of cars.

All this is too clear for it to be necessary to expand on the importance of keeping the interior of the car clean and tidy and on the need to immediately eliminate any fires that have formed, partly from a lack of cleanliness, partly from the careless handling of various kinds of garbage, foci, introducing impurities harmful to the body of passengers into the air of the car.

Obviously, ventilation and ventilating come into their own only when the requirements for cleanliness of cars are met, and until then, both, in most cases, turn out to be invalid. I have already cited Professor Pettenkofer's sharp, but in this case very apt expression on this subject, but now I pay attention to it because many people see ventilation as the main and even the only means for improving the air of cars, without attaching due importance to everything else; it is also obvious that by the mere observance of even impeccable cleanliness, we will not go far along the path to the goal. Where we have to deal with the *inevitable* steady, periodic or constant release into the air of substances that contribute to pollution of the latter, we must turn for help to ventilation, which in this case alone can bring the air of the car closer, in quality, to the required one. As for disinfection of cars, this latter, in the current state of the issue, as an independent measure for our purposes, should recede into the background.

We have already firmly established ourselves in the concept that the main factor in deterioration of car air is dust, and especially organic dust. This circumstance makes us, first of all, strive to clean the air of cars from dust. It is impossible to completely clean the air from dust, but there is a full opportunity to significantly reduce its amount by taking advantage of its physical properties.

Generally speaking, cleaning of cars from dust, dirt, etc. during their service costs, with a certain passenger traffic on a given road, depending on the number of cars serving and, as a result, more or less waiting for setting to the train. However, even on such roads, where the cars are outside the trains for a sufficient time to clean them, and where there are artels of workers special for this purpose, cleaning of cars has a character of an accident; this circumstance must be attributed to the absence of any system in this matter; where there is no such helmsman, the means help little.

I will not dwell on such ordinary things as washing the floors in the cars, knocking out and airing the seat cushions, rugs, etc.; the rational use of these measures practiced by all railways presents absolutely no difficulty. Here I want to make only a few remarks, which to a large extent could help the cause of reducing dust in cars.

First of all, in this regard, soft cushions of passenger seats draw our attention. Everyone knows that upholstered furniture contains a lot of dust, that this dust, generally speaking, cannot be knocked out, since the inner stuffing of pillows (hair, grass, etc.) itself is a collector and a constant source of dust, it is easy penetrating outside. Those who have had to be present when passing an old hair through a scutching machine know what a large amount of fine dust is emitted.

It is known that the wooden frame of the pillow, in which, together with springs, is placed, its inner stuffing, both from below and from above, is usually covered with a rare hemp or linen fabric, which is not able to keep dust from freely penetrating it outwards with any blow to the pillow, even a small one, which is usually accompanied by the descent of a passenger into the seat, not to mention the absorption of various gases by upholstered furniture. All this points to the urgent need to replace the rare fabric with a dense one, no matter whether it is carefully dyed tarpaulin, good oilcloth, or anything else of the kind; only on top of a cover as less permeable to dust as possible, a fine upholstery should be applied, which in this case will be covered mainly by external dust, and this latter can be easily knocked out and removed with a slightly damp cloth[10].

Everyone knows that in cars equipped with upholstered furniture, the air is extremely thin even after ventilation. Often it was necessary, using the sense of smell, to recognize the air of

[10] Upholstered spring furniture without stuffing is currently used on American roads, drawings of such furniture can be found in the American journal «*Nation, Car and Locom. Builder*» (1891, Vol. XXII, Number 5 Supl).

class I and II, going in a train without passengers (this is especially noticeable in cars with compartments), worse than in a class III car filled with the so-called pure public. In the work of Dr. Taratkevich we find that the air in a class II car, given the corresponding number of passengers, would be incomparably worse than in a class III car. New cars built on Nikolaevskaya railway eliminate the possibility of looking for the main reason for this circumstance in the leakage of window frames, doors, etc.

Sources of dust in cars are also various kinds of panels, floorings, etc. Rope rugs (resin) should certainly not be allowed in cars, since they absorb a lot of dust that is exposed to moisture, sputum, etc., decomposition, dust from blows and friction with feet rises into the air and infects it. The best rugs are thick tarpaulins, from which it is possible easily to wash off dust and dirt from time to time with a rag or mop.

On some roads, it is customary to wash walls and ceilings with water from time to time, whether wooden or upholstered with oilcloth. For this purpose, a more convenient and expedient method can be recommended. A sleeve is inserted into each car in turn, equipped with a metal head with extremely small holes; by spraying water, they moisten the air, walls, furniture, etc. When the dust settles, then carefully collect it from the furniture with damp rags, and from the walls and ceiling with rollers, proposed by Dr. Oswald-Wolf, wrapped in a sponge, cotton wool or cloth and placed in a fork equipped with a long handle; the winding obviously requires thorough washing as it gets dirty.

Since ventilation of cars empty of passengers plays a very important role in the sense of improving the air of cars, it is necessary to arrange windows in such a way that they can be conveniently opened at any time of the year. The best type in this regard is the drop frames. This type of frames, practiced on various railways, received the right of citizenship on Nikolaevskaya railway.

From the foregoing, we see that the tasks of ordinary car disinfection, in the current state of the issue, are reduced to a minimum and that cleaning of cars and ventilation given earlier, to which we now turn, are the main areas that completely absorb our attention in the issue of air sanitation of passenger cars.

The immediate task of car ventilation is not to restore normal composition of the air, which is obviously unattainable, but to remove and disperse harmful impurities in car air, mainly organic dust, which serves as a medium for various kinds of organic processes. The scattering of dust particles caused by ventilation is in itself capable to some extent of weakening the energy of the processes of development and decomposition. Duclos says that dispersal of germs kills their action; the same must be said about those putrefactive fungi and spores that form whole colonies that float in the air of the car.

The next task of ventilation, no less important, but to which very little attention has been paid until recently, is to help maintain the thermal equilibrium of the body with the help of a steady exchange of air. Neglecting this last task still feeds such theories as the theory of heating and ventilation with heated air brought to body temperature or even higher.

Consideration of this still far from clarified problem is not included in the program of this study, and I will allow myself to touch on it only in passing insofar as it is necessary for judging the ventilation practiced in cars with heated air; I now turn to the next problem of ventilation.

It is quite clear that in the car, if it were a completely isolated space, not communicating with the outside air, the critical moment for breathing would finally come sooner or later – depending on the number of passengers and on the volume of the car, more correctly, on the initial volume of fresh air…

Now let's move on to the consideration of those devices that achieve artificial ventilation of cars.

All devices of this kind are divided into two main groups: the first of them is based on direct pushing of fresh air into the car by the force of the wind, the second – on exhaustion of spoiled air from the car also by the force of the wind; it is assumed that the same amount of fresh air enters the car through natural ventilation. Combinations of ventilation devices of both groups are rare.

We know that the work of all such apparatuses, acting by the force of air currents, is closely dependent on these latter, and that this circumstance determines the inconstancy of their action.

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