

U.S.S.R. LITERATURE ON AIR POLLUTION AND RELATED OCCUPATIONAL DISEASES

Volume 4

A SURVEY

by

B. S. Levine, Ph. D.



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B. S. Levine, Ph. D.

**U.S. Public Health Service
(Health, Education, and Welfare)
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AUGUST 1960

Other books and surveys dealing with U.S.S.R. air pollution and related occupational diseases available from U. S. Department of Commerce, Office of Technical Services, Washington 25, D. C.

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Russian-English Medical Dictionary. By Stanley Jablonski. Edited by B. S. Levine.	\$11.00
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FOREWORD

The organization of the material in Volume 4 is based on the same principles as in Volume 3, a brief statement of which was presented in the Foreword to that Volume (O.T.S. No. 60-21475). Papers which appeared in Zhurnal Prikladnoi Khimii and similar journals, which in the opinion of the undersigned had a direct and in some cases indirect relation to some phases of air pollution, were given greater representation in Volume 4.

The reader's attention is called to Section VI - Sanitary Clearance Zones, and to Section VIII - Bactericidal Substances Emitted by Living Plants. In connection with the material presented in Section VI it is interesting to note the following: In the introduction to the second edition of his book "Atmospheric Air Pollution, Its Origin and Prevention", A. R. Meetham states: "Another fruitless effort to rid London of smoke was made by the philanthropist John Evelyn in the reign of Charles II. He proposed that the factories of brewers, dyers, lime burners, salt and soap boilers, and others of the same class, should be moved lower down the Thames; and that Central London, as we know it, should be surrounded by a green belt thickly planted with trees and scented flowers." This, in essence, is the idea and principle of the Sanitary Clearance Zones.

The papers presented in Section VI, though few in number, will nevertheless enable the English readers to form a basic picture of how the U.S.S.R. sanitary-hygienic authorities are endeavoring to put the principle of Sanitary Clearance Zones, or Sanitary Green Belt Zones, into practice on a national scale. It is to be noted in this connection that all sanitary codes in the U.S.S.R. are fluid and are subject to revision in accordance with pertinent developments. This also applies to the prescribed widths of Sanitary Clearance Zones. The classification presented by M. S. Goldberg in the first paper of Section VI appeared in 1948. At the time this volume was completed, the undersigned received a copy of the 1953 compendium of U.S.S.R. sanitary codes which shows that the sanitary clearance zone classification has been revised. The revised list will appear in Volume 5.

The material in Section VIII was selected from a book entitled "Phytoncides and Their Role in Nature". The undersigned selected from its content papers which had a bearing on natural air purification from bacteria. It is hoped

that it will prove of interest to American and English readers, and that it will prompt some investigators to make studies of their own in the field of "Phytoncides".

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Washington 15, D. C.

Note: By way of grateful acknowledgement each item in this collection is headed by the original title (in translation), the name of the author or authors, institutional affiliation and periodical or book from which item was selected. The volume, issue number, year of publication and inclusive pages are indicated for the convenience of those who may wish to consult the Russian original or make full reference to same.

B. S. Levine.

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Rapid Determination of Small Quantities of Dimethylaniline in the Air.

By

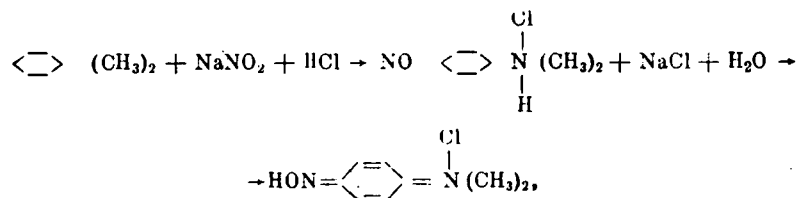
N. I. Fomicheva and P. A. Mel'nikova.

(All-Union Scientific-Research Institute of Labor Protection, VTsSPS).

Gigiena i Sanitariya, No. 5, 49-52, 1952.

Dimethylaniline [$C_6H_5N(CH_3)_2$] is a liquid of 0.962 specific gravity at 15° and boiling point of 193° at 760 mm pressure; it has an unpleasant odor. The vapor tension of dimethylaniline at 40° is about 2.5 mm of mercury, and the vapor is 4.2 times as heavy as air. Dimethylaniline is used in the aniline-dye industry, the pharmaceutical and rubber industries. Its effect on the organism is similar to that of aniline; it is predominantly a blood poison; intoxication results from inhalation of its vapor and from contact with the skin.

Of the several reagents which produced color with dimethylaniline, only one has been used for its colorimetric determination, as suggested by A. S. Zhitkova in 1927. This determination was based on the reaction of dimethylaniline with nitrous acid in hydrochloric acid solution, in which hydrogen in the para position was substituted by a nitroso group, forming a water soluble paranitroso-basic salt, according to the scheme shown below:



The resulting compound imparts to the solution a yellow color the intensity of which can be determined colorimetrically. Dimethylaniline can be absorbed from the air by hydrochloric acid. This method requires the aspiration of large air volumes and, therefore, considerable time and bulky equipment. The same reaction forms the basis of the recently proposed determination of dimethylaniline and of other tertiary amines in the presence of primary and secondary amines with the aid of photoelectric absorptiometer.

On the basis of data found in the literature a rapid colorimetric method

was developed for the determination of dimethylaniline in the air, by applying the above mentioned color reaction of paranitrosobasic salt in hydrochloric acid solution. In testing hydrochloric acid concentrations of 10%, 5% and 1% for use in the preparation of a standard solution of dimethylaniline it was noted that during the formation of paranitrosobasic salt deepest yellow color was obtained with 1% hydrochloric acid. It was also noted that dimethylaniline was fully retained in the first 1% HCl absorber.

The possibility of the colorimetric determination of dimethylaniline in small volume air samples was established first; this was followed by the development of precise methods for the preparation of low concentration standard scales. Standard solution was prepared with 1% hydrochloric acid containing 0.01 mg dimethylaniline per 1 ml, from which was prepared a standard scale containing correspondingly 0, 0.001, 0.002, 0.004, 0.006, 0.008 and 0.01 mg dimethylaniline per 1 ml. Into each test tube of the scale 0.2 ml of 10% sodium nitrite solution was added. The maximum color intensity developed within 5 minutes and no color fading could be detected after 3 days. Differences in the color intensity in the tube were easily perceptible. Smaller amounts of sodium nitrite produced unstable colors.

A permanent artificial standard scale was prepared from 0.05% aqueous solution of sodium dichromate, as shown in Table 1.

T A B L E 1.

Artificial scale for the determination of dimethylaniline.

Ml of 0.05% K_2CrO_4 solution	0.0	0.1	0.2	0.4	0.6	0.8	1.2
Ml of water	1.2	1.1	1.0	0.8	0.6	0.4	0.0
Mg of dimethylaniline	0.0	0.001	0.002	0.004	0.006	0.008	0.01

The artificial scale was first checked against the natural scale prepared as previously described and errors and deviations were corrected accordingly. Several lots of K_2CrO_4 were tried; all were found satisfactory. The color intensity of artificial scales kept in tightly stoppered tubes did not change with time.

The determination can be speeded up by absorbing the dimethylaniline into a combined hydrochloric acid and sodium nitrite solution so that the color may develop directly in the absorber while the air is being aspirated.

It was established that the aspiration of pure air through two absorbers containing the combined reagents mentioned above at a temperature of 18 - 40° and an aspiration rate of 2 - 15 li/hour did not produce any color in the solution due to the formation of nitrogen oxides which tended to persist in the absorbers. Aspirating air containing dimethylaniline through absorbers with a mixture of acid and sodium nitrite and through absorbers containing only acid (sodium nitrite was added to the absorbers after the end of absorption) produced similar results under otherwise identical conditions. It was noted that after standing for 24 hours the mixture of acid with sodium nitrite lost some nitrous acid; hence, the absorber should not be filled with this mixture in advance.

Air containing 0.114 - 0.002 mg/li of dimethylaniline was aspirated through the consecutively arranged absorbers, each filled with a mixture of 1 ml of 1% hydrochloric acid and 0.2 ml of 10% sodium nitrite; 70 to 200 ml of air was aspirated at the rate of 10 to 100 ml/min until a pale yellow color appeared in the first absorber. Five minutes after the collection of the sample was completed the color intensities developed in the absorbers were compared with the permanent standard scale. No dimethylaniline was detected in the second absorber.

Known concentrations of dimethylaniline were determined colorimetrically using the natural and the permanent artificial standard scales. As seen in Table 2 in either case the results were satisfactory.

T A B L E 2.

Checking the method of dimethylaniline determination with known concentrations in mg.

Mg methyl- aniline taken	Mg dimethylaniline found		Mg methyl- aniline taken	Mg dimethylaniline found	
	Natural scale	Artificial scale		Natural scale	Artificial scale
0.0005	-	0.0005	0.004	0.004	0.004
0.001	0.001	0.001	0.004	0.004	0.004
0.002	0.002	0.002	0.005	0.005	-
0.002	-	0.002	0.006	0.006	0.007
0.003	0.003	0.003	0.008	0.008	0.008

The rapid method for the determination of dimethylaniline was checked at a pharmaceutical plant and in a workshop which used dimethylaniline. The air was drawn with the aid of a 200 ml microaspirator through a single microabsorber containing 1 ml of 1% hydrochloric acid and 0.2 ml of 10% sodium nitrite solution until a pale yellow color appeared. After five minutes colorimetric determinations were made on the location using the artificial standard scale. Conditions under which samples were collected and the results of dimethylaniline determinations are presented in Table 3.

T A B L E 3.

Dimethylaniline in the air of working premises.

Air vol. in ml	Minutes of sample taking	Rate in ml/min.	Temper- ature	Mg/li of di- methylaniline in the air	Place of sampling
2,000	23	87	36°	0.002	At place of dimethylaniline distillation at beginning of work
1,000	11	91	31°	0.004	At dimethylaniline drum
1,000	10.5	95	31°	0.003	At dimethylaniline drum
1,000	10	100	31°	0.0025	Near dimethylaniline and toluol distillation apparatus
1,000	10	100	32.5°	0.004	In the center of the department
800	8	100	32.5°	0.0025	In the center of the department
600	5	120	32.5°	0.017	Near open apparatus for the treatment of dimethylaniline-toluol mixture with alkali
400	3	130	33°	0.01	Ditto, during pumping into sedimentation tank
600	7	86	30°	0.0033	On the work bench
400	4	100	37°	0.012	Near dimethylaniline distillation apparatus in the middle of day
800	11	73	34.5°	0.005	In the center of the department

Toluol, methanol and dichlorethane vapors did not interfere with the dimethylaniline determinations. The same was true of the presence in the air of aniline, monomethylaniline, ether or benzene. Diethylaniline produced an identical color.

Conclusions.

1. A rapid colorimetric method was developed for the determination of small quantities of dimethylaniline in the air, based on the formation of a yellow colored paranitrosobasic salt; the air aspiration and the colorimetric estimation with the aid of an artificial scale can consume approximately 15 to 20 minutes; the dimethylaniline content per 1 ml of the air must be within 0.001 - 0.01 mg.

2. The method suggested is simple, requires no complex equipment and is suitable for dimethylaniline determination in the air of industrial premises at concentrations in the order of hundredths and thousandths of a milligram per liter.

The Polarographic Method in Sanitary-Hygienic Investigations.

By

M. S. Bykhovskaya and M. I. Poletaev.

(Institute of Labor Hygiene and Occupational Diseases of the Academy of Medical Sciences, U.S.S.R.).

Gigiena i Sanitariya, No. 12, 47-50, 1952.

The purpose of the investigations was to establish optimum conditions for the polarographic determination of small quantities of lead, zinc, copper and cadmium. The study was made with the aid of a recording polarograph of the Odessa Institute of Rare Metals, employing model No. 5 with a mirror galvanometer of 3.7×10^{-9} A sensitivity, having a capillary with a constant mercury

dropping rate of 10 drops per 15 seconds. Polarographic determinations were made using an interior anode, as well as an outer calomel electrode, connected with the analyzed solution through a salt-agar bridge. Temperature fluctuations did not exceed 1° .

Determination of lead. Regardless of the method by which lead was absorbed from the air and of its subsequent separation from the absorber, the study dealt with the problem of minimal determinable lead quantities in different solutions used as basic electrolytes.

In the first step of the investigations the oxygen present in the solution under study was removed by blowing through it pure hydrogen for 20 - 30 minutes. A few drops of 1% glue or agar were added to the solution to prevent excessive foaming. In the study 2 - 5 ml of the solution were used contained in an electrolyzer.

For the absorption of lead from the air under field conditions, industrial sanitary laboratories have been using solid absorbers, such as absorbent cotton, glass wool, filter paper, and the like, subsequently leaching the lead out with 5% solution of nitric or acetic acid. Accordingly nitric and acetic acids were used as basic electrolyzers. Solutions of these acids containing 2 to 50 mg of lead per liter were tested first. The results indicated that a 5% HNO_3 solution was the most suitable medium for the polarographic determination of lead, since in the presence in the solution of 2 mg or more of lead the maximum diffusion current, as reflected by the amplitude of the wave, was proportional to the lead concentration in solution.

Fig. 1 is a curve of the functional relation between the amplitude of polarographic waves and the lead concentration in a 5% nitric acid solution. Minimum determinable lead concentrations amounted to 2 - 3 mg/li; which corresponds to 0.01 - 0.015 mg of lead per 5 ml of the solution. Half-wave potential of a nitric acid lead solution in relation to a standard calomel electrode was equal to 0.47 V. Working in the region of highest galvanometer sensitivity it is best to use agar to prevent foaming, since glue is frequently contaminated with substances which interfere with the examination of the solution under investigation.

Having established the possibility of determining lead content in the presence of nitric acid, additional tests were made for the polarographic determination of lead in acetic and hydrochloric acid. Such tests also yielded

clear-cut polarographic waves with half-wave potentials in relation to a standard calomel electrode, in an acetic acid solution equal to 0.36 V and in hydrochloric acid solution equal to 0.45 V. In Fig. 2 are presented curves of the functional relation between wave amplitudes and lead concentrations in 5% acetic and hydrochloric acid solutions as basic electrolytes. The curves indicate that a linear relation existed between the lead concentration in solution and the wave amplitude.

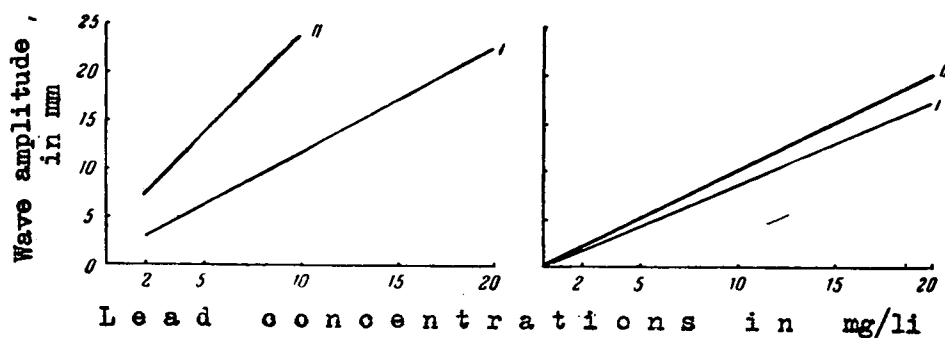


Fig. 1. Galvanometric sensitivity:
I - 1/10, II - 1/5.

I - Hydrochloric acid 5%
II - Acetic acid 5%
Fig. 2.

Analysis of the results lead to the conclusion that all the acids tested could be used as basic electrolytes for the polarographic determination of small quantities of lead.

However, experiments in the recovery of the lead from the absorbers with acids and its subsequent polarographic determination demonstrated that best results were obtained with 5% nitric acid solution. If the quantity of lead in the sample is no less than 0.1 - 0.2 mg and the volume of nitric acid after recovery does not exceed 20 - 30 ml, the polarographic determination can be carried out directly in this solution, after the removal of suspended admixtures by centrifugation. Acetic acid in 5% concentration can be used as a basic electrolyte for the determination of lead content in skin or work clothes wash water.

It must be pointed out that in attempting to determine the lead content in the air approximating the maximum permissible concentration of 0.00001 mg/li, the described polarographic method of direct lead content determination following its recovery from the absorber by means of acids proved to be inadequate.

In such cases the sample should be first concentrated by evaporation to dryness and the residue redissolved in a suitable small volume of the basic electrolyte.

Lead nitrate was dissolved in a buffer solution consisting of 30% acetate of ammonium and 1% acetate of sodium dissolved in 1% acetic acid solution; this buffer solution is generally used in the determination of small quantities of lead in samples containing lead chromate. Polarograms obtained indicated that both solutions could be used in the polarographic determination of lead. Most clear-cut polarographic waves were obtained with 30% ammonium acetate solution at $\text{pH} = 6.6 - 7.0$. The half-wave potential in relation to the standard calomel electrode in a 30% ammonium acetate solution was 0.58 V and in 1% sodium acetate 0.41 V.

In Fig. 3 are presented curves of the functional relation between diffusion current and lead concentration in 30% ammonium acetate solution and in 1% sodium acetate solution in 1% acetic acid.

Supplemental tests were made to determine the effect of copper and zinc on the determination of lead. Analyses of solutions in which lead, zinc and copper were present simultaneously indicated that copper and zinc in concentrations exceeding the content of lead by two or more times did not interfere with the polarographic determination of lead. It was also established that separate determinations of copper, lead and zinc were possible only in a 30% ammonium acetate solution and in 1% sodium acetate solution in 1% acetic acid. As seen from Fig. 4, polarographic waves of copper, lead and zinc were distinct, and no shifting on the half-wave potential nor fluctuations in the polarographic wave amplitudes were noted. In 5% solutions of nitric and acetic acid, copper and zinc could not be determined; only the lead wave was clearly expressed in the polarogram. Data contained in the literature on the possibility of determining lead presented some interesting facts.

According to Teisinger lead albuminate was destroyed in the blood by the addition of hydrochloric acid. In this way Teisinger was able to determine polarographically lead recovered from the blood. In checking this method only faintly expressed lead waves were noted. Blood analyses of animals which received lead chronically revealed no lead either in the whole blood or in the plasma after the separation of the erythrocytes. Thus, Teisinger's results could not be confirmed. Only after the destruction of organic substrate were

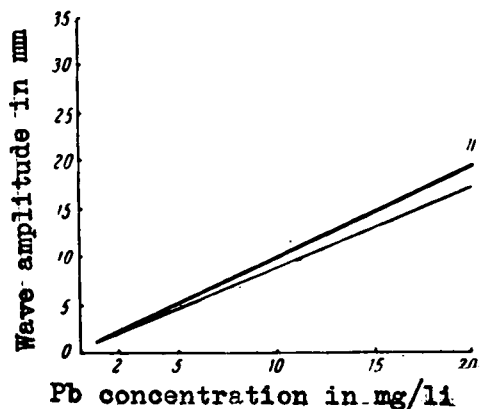


Fig. 3. I - Ammonium acetate 30%; II - 1% sodium acetate in 1% acetic acid soln.

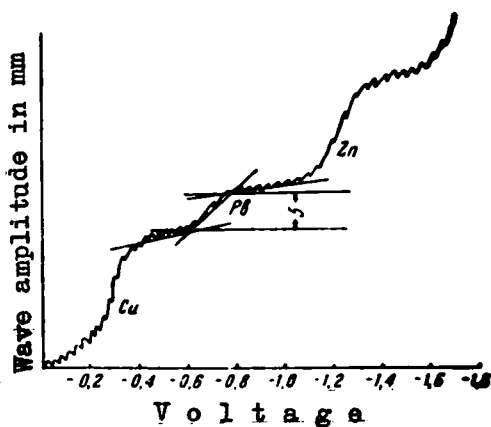


Fig. 4

characteristic lead waves obtained. This was done with a mixture of sulfuric and nitric acids and using 30% ammonium acetate as the basic electrolyte medium.

Determination of zinc, copper and cadmium. For the polarographic determination of zinc and cadmium a solution of ammonium was used as the basic electrolyte medium in accordance with recommendations found in literature. Zinc and cadmium compounds were absorbed from the air onto solid absorbers from which they were removed with the aid of acids. In the polarographic determination of these metals the basic electrolyte medium consisted of 20% hydrochloric acid neutralized to a slight excess by strong ammonia. The oxygen present in the solution was bound to a small amount of added dry sodium sulfide; two drops of 1% agar were added to prevent excessive foaming. The half-wave potential in relation to the standard calomel element in the test solution was 0.6 V for cadmium and 1.2 V for zinc. The lowest determinable quantity of cadmium was 1 mg/li and 2 mg/li for zinc. At lower concentrations the functional relation between concentration and diffusion current became irregular.

The results demonstrated that under above described conditions small quantities of copper and zinc could be reliably determined when present simultaneously. In the usual chemical analytical procedures their separation presents difficulties. Polarograms presented in Fig. 5 manifest distinct and easily measured waves.

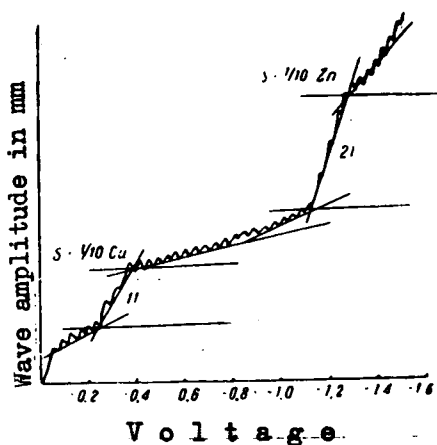


Fig. 5.

On the basis of the results obtained it is recommended that in the determination of zinc, copper and cadmium absorbed from the air onto the solid absorbers should be removed with 20% hydrochloric acid solution; the solution should then be filtered, neutralized with concentrated ammonia to slight excess and the polarographic determination made after the addition of a few drops of 1% agar solution. In cases of low concentrations of the isolated metals, the hydrochloric acid should be evaporated to dryness and

the residue dissolved in 1 - 2 ml of hydrochloric acid and neutralized with ammonium.

Conclusions.

1. It was demonstrated that polarographic determinations of small quantities of lead in the air can be made by using 5% nitric acid solution, 30% ammonium acetate solution and 1% sodium acetate in 1% acetic acid as the basic electrolyte medium. Zinc and copper did not interfere with the polarographic determination of lead.
2. It is recommended that 30% ammonium acetate be used as the basic electrolytic medium at pH of 6.6 - 7.0 in the separate determination of lead, zinc and copper.
3. A 5% acetic acid solution is recommended for obtaining test wash samples from the skin or from working clothes.
4. Lead in blood can be determined only after the destruction of the organic substrate to which it is bound; a 30% ammonium acetate solution is recommended as the best basic electrolyte medium.
5. Small quantities of zinc, copper and cadmium can be determined polarographically in ammonia solution of ammonium chloride when present individually or simultaneously.

Spectrographic Determination of Manganese in Animal Organs and Tissues.

By

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Gigiena i Sanitariya, No. 10, 48-50, 1954.

In this paper are presented data obtained by the spectrographic method in the determination of manganese in organs and tissues of animals suffering of manganese intoxication. Tests were conducted with three groups of rabbits: the first group, consisting of 6 rabbits, was not treated, and served as the control group. Four rabbits of the 2nd group were injected hypodermically with small doses of manganous chloride over a period of one month to a total of approximately 60 mg/kg of body weight. Some of the rabbits died during the injections; the organs and tissues of these animals were examined to establish the distribution of manganese in the organism when introduced parenterally in solution. Four rabbits of a 3rd group were exposed for 6 months to the inhalation of oxide of manganese in the form of highly dispersed aerosols obtained by vaporization of manganese dioxide by an electric arc; the rabbits were exposed daily for one hour to 0.05 mg/li concentration of manganese in the experimental chamber. At the end of the experiment the rabbits were killed and their organs analyzed for the content of manganese. Table 1 presents averages of 8 - 12 analyses for each organ.

The results indicated that chronically inhaled manganese aerosol accumulated in the blood and in the cerebrum and that manganese passed from the lungs, where it is retained in the insoluble form, into the blood. This fact is particularly significant since under actual conditions intoxication is caused by the inhalation of the insoluble manganese dust.

Accumulation and distribution of manganese in tissues and organs was studied by the spectral method. The Hilger type of spectrograph was used in this investigation, equipped with a quartz lens of 10 cm focal length. The electric arc image was projected on a background with a rectangular aperture facing the collimator slit located 3 cm from it, so that the points of carbon electrodes would not run into the slit. This was necessitated by the fact that the radiation coming from the incandescent electrode points is replete with molecular spectral

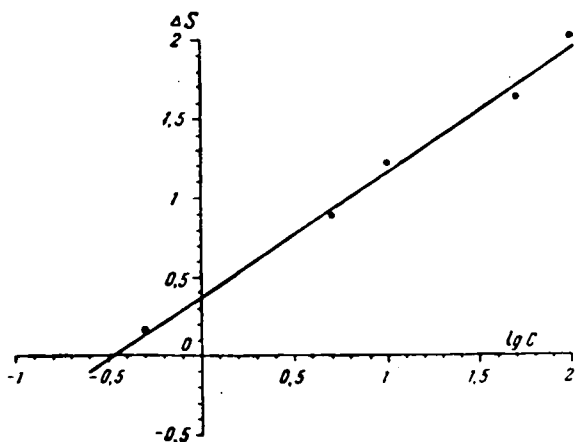
T A B L E 1.

Manganese content in mg% in organs and tissues of rabbits.

Organs	Controls, first group	Subcutaneous manganese injection, second group	Chronic inhalation exposure, third group
Heart	0.4	1.5	0.4
Lungs	0.2	1	0.43
Kidneys	0.225	3	0.248
Spleen	0.18	1.5	0.2
Liver	0.512	5.6	0.6
Cerebella	0.2	5.4	0.3
Diencephalon	0.029	8	0.03
Medulla oblongata	0.3	5	0.3
Spinal cord	0.4	4.5	0.4
Blood	0.05	29.8	0.3

bands which seriously hamper the analysis of the spectrum. The illuminating condenser lens is provided with a diaphragmal iris for the control of degree of illumination coming through the spectrograph slit. The position of the electrode points, set at 4 mm distance between them, were indicated on the background. This facilitated the control of distances between the electrode on a constant standardized basis. The distance between the arc flame and the collimator slit was about 20 cm. The arc was fed by an alternating current and supplemental activation. The arc intensity was kept constant at an 8 A level. A slit 0.02 mm wide was used for qualitative analysis, and a slit 0.1 mm wide for quantitative analysis. In most cases the analytical bands were selected from the most intensive spectral bands, or, the so-called, end lines. Spectral bands 2576.1A, 2593.7A, 2605.A are recommended for use in manganese determinations.

In the study of manganese distribution in the organism an 0.02 g per 0.02 ml solution of BeSO_4 was used as the standard. The work was carried out by the method of triple standard of comparison. Such a procedure records on one plate the spectrum of the substance tested together with spectra of each of three standard solutions of different strength. Solutions of MnSO_4 were used in the preparation of the standard. The range of standard concentrations was chosen in relation to the expected manganese concentration in the material investigated.



Calibrated graph.

The spectra of standards were used in plotting a standard curve of comparison. It is of utmost importance that the standard and tested Mn concentrations be burned and photographed under identical conditions.

The standard curve is prepared as follows: the relative darkening of duplicate bands of standards were determined microphotometrically and the logarithm of $\frac{d_1}{d_2}$ was recorded, where d_1 =

microphotometer position of the beryllium band and d_2 = microphotometer position of the manganese band. The value thus determined, called the extinction difference (blackening), was plotted on ΔS ordinate; logarithms of standard concentrations ($\lg C$) were plotted on the abscissa.

All calculations for the calibrated graph are presented in Table 2.

TABLE 2.

Data for the construction of the graph.

d_1	d_2	$\Delta S = \lg \frac{d_1}{d_2}$	Mn. concn. in γ	Log C
16.8	0.15	2.05	100	2
14.9	0.35	1.63	50	1.7
12.7	0.8	1.2	10	1
17	2.3	0.87	5	0.7
16	10.8	0.17	0.5	-0.3

For spectra of unknown manganese concentrations photographed on the same plate, the difference in the darkening (extinction) of the analytical pair was determined as described, and their values were plotted on the axis of extinction. The corresponding point was established on the standard curve; the values of the unknown concentrations were determined with the aid of this point.

This study was made with spectrally pure carbon electrodes 6 mm in diameter. A hole was drilled in each carbon 3.5 mm in diameter and 4 mm deep.

Hygroscopicity of the carbons was eliminated by the use of cupferron and other suitable substances, and of collodion in particular. Solution of the standard was poured into the drilled hole and the carbons were dried. The carbon electrodes thus prepared were then filled with the ash of the organ under investigation and used in the quantitative analysis. Preliminary tests indicated that complete vaporization of the test samples from the drilled carbon electrode opening occurred in 6 minutes. Positive films of 2 - 3 X-D sensitivity were used. These photofilms had a constant contrast range within 2500 - 3100 Å. Hilger's microphotometer was used in the determination of the intensity of spectral line extinction (darkening).

Samples for analyses were ashed in the usual way, and the weight of the ash determined in relation to the original weight of the raw tissue. A weighed portion of the ashes was then used in the final spectral analysis as described above.

Conclusions.

1. Manganese was found in all tissues and organs of rabbits living under normal environmental and nutritional conditions.
2. The subcutaneous administration into rabbits of soluble Mn salts brought about Mn accumulation in the kidneys, liver, cerebrum and, particularly, in the blood.
3. Following the inhalation of aerosolized manganese dioxide the manganese content increases in the tissues of the lungs, the cerebrum and, particularly, in the blood.

Determination of Paratoluidine Vapors in the Air of Industrial Premises.

By

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Gigiena i Sanitariya, No. 11, p. 48, 1954.

Paratoluidine is used widely in the production of dyes, liquid fuel, pharmaceuticals, etc. It is a white crystalline substance which melts at 45° and boils at 200.4° ; its specific gravity is 1.058. The maximum permissible concentration of paratoluidine vapor concentration in the air of industrial premises was set at 0.005 mg/li. Paratoluidine reacts with bichromate of potassium in sulfuric acid medium, with paranitrophenyldiazonium and with ferric chloride. Experiments were conducted to establish the suitability of some of the above reactions for the quantitative determination of paratoluidine in the air; the results were as follows:

1. Potassium bichromate in sulfuric acid produced a yellow color not specific for paratoluidine; the reaction proved to have a low sensitivity.

2. In the presence of paranitrophenyldiazonium paratoluidine produced a yellowish-pink azo dye; the reaction's sensitivity was 0.001 mg in 5 ml; the reaction was not specific and the presence of aniline and of other aromatic amines interfered with it.

3. In the presence of ferric chloride in hydrochloric acid medium paratoluidine produced a brown to pink-red color; the sensitivity of this reaction was on the level with the one above.

A quantitative colorimetric method for the determination of paratoluidine in the air was developed based on this reaction. The only advantage of this method was the low cost and easy availability of the reagents; as was the case with the previous reaction, the presence of aromatic amines caused some interference.

The paratoluidine vapors are aspirated through two consecutively connected Petri absorbers, each containing 10 ml of 0.1 N hydrochloric acid solution. The air is drawn through the absorbers at the rate of 30 li/hour. For the detection of 0.005 mg/li of air, which is the maximum permissible concentration,

it is necessary to draw through the absorber no less than 10 liters of air.

For the determination of paratoluidine content in each of the two absorbers 5 ml are taken from each absorber and placed into a test tube. A standard scale is prepared simultaneously. Into a series of colorimetric test tubes are placed 0.1, 0.2, 0.4, 0.6, 0.8 and 1 ml of a standard solution containing 0.1 mg of paratoluidine per 1 ml; the volume of fluid in all test tubes is brought up to 5 ml with 0.1 N solution of hydrochloric acid.

5 ml of 0.1 N hydrochloric acid solution is poured into the first, or control, test tube. Thus, a scale is obtained with a paratoluidine content ranging from zero to 0.1 mg per 5 ml.

Then, into each of the test tubes of the standard scale and of the samples are added 0.1 ml of a 20% ferric chloride solution; the content is stirred with a glass rod or shaken, heated to boiling and cooled to room temperature by submerging into cold water. Colorimetric determinations are made as usual after the full development of brown to brown-red color.

Spectra and Spectrophotometric Analysis of Chlorinated Organic Compounds.
Report. The Determination of Chlorex in Dichlorethane.

By

Ts. N. Roginskaya and A. I. Finkelshtein.

Zhur. Anal. Khim., Vol. XI, No. 5, 602-605, 1956.

Analysis of a mixture of chlorex, i.e., β,β -dichloroethyl ester, and of dichlorethane by chemical methods is a complex problem. The fractional distillation of the mixture by Engler's method may produce only approximate results. A more elaborate distillation is time consuming, and, therefore, not suited for use in production control. On the basis of the marked difference in the molecular structure of chlorex and dichlorethane, it can be expected that one of the methods of molecular spectral analysis might offer the solution to the given problem. In this connection a detailed investigation of the

spectral properties of chlorex was undertaken; the results of this investigation are presented in this report.

Among all the reports found in the literature only one [1], dealt with the ultraviolet spectrum absorption band of chlorex dissolved in hexane. In the work described chlorex was used which had a boiling point of 175° ; d_4^{20} 1.200; n 1.4562; according to literature the data are: d_4^{20} 1.220 - 1.222; n 1.4560 - 1.4570; boiling point 178.5° . A quartz photoelectric spectrophotometer SF-4 was used for the analysis of the absorption spectra, and the analytical work in the ultraviolet region. A detailed description of the instrument, as well as the descriptions of other domestic spectrophotometers used in the present work are described in Prokofiev's [2] and Khrashanovskii's reports [3]. The absorption spectra of chlorex in ethyl alcohol and in dichlorethane, as well as the absorption spectrum of dichlorethane, are shown in Fig. 1.

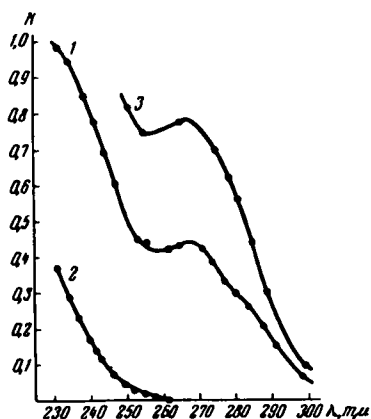


Fig. 1. Absorption spectra in the ultra violet region.
1 - Chlorex in ethylol; 2 - dichlorethane in alcohol; 3 - chlorex in dichlorethane

It is seen from Fig. 1 that the absorption of the chlorex solution in dichlorethane has its maximum at 267.5 mμ. Since dichlorethane produces no noteworthy absorption in this region the above wave length can be conveniently used for analytical purposes. The calibration curve shown in Fig. 2 was constructed with the aid of artificial mixtures.

The results of the analyses of artificial mixtures shown in Table 1, indicate that the mean relative error amounted to 4.0%. The analysis can be completed in 3 to 5 minutes, and the sensitivity, using an absorbing layer of 1 cm thick, is 0.2%.

This method is not suited for the analysis of substances containing resins, tars or rubber. Removal of the interfering admixtures by activated charcoal yielded no desired results. Therefore, a new method was developed for the analysis of substances containing the above mentioned constituents, based on the absorption spectra in the infra-red region. In the development of this method spectrophotometer IKS-11 was used, which is equipped with a rocksalt prism and a 0.1 mm thick potassium bromide cell. The temperature at the source

TABLE 1.

Chlorex %		Error %	
Taken	Found	Absolute	Relative
4.00	4.05	+0.05	1.25
13.30	13.0	-0.30	2.26
8.40	8.20	-0.20	2.38
7.40	7.25	-0.15	2.03
2.50	2.50	0	0
1.20	1.30	+0.10	8.35
1.62	1.70	+0.08	4.95
3.36	3.20	-0.16	4.75
4.63	4.35	-0.38	8.2
5.57	5.30	-0.27	4.85
7.95	7.75	-0.20	2.52
9.32	9.45	-0.37	3.77
12.12	15.75	-0.37	3.06
1.96	1.90	-0.06	3.06
3.98	3.85	-0.13	3.26

Average relative error 4.0.

A single analysis was made in 15 to 20 minutes, the sensitivity was 0.3%, and the mean relative arithmetical error ~5.5%. Analytical results of the artificial mixtures are shown in Table 2.

of radiation ranged between 1600 to 1700⁰.

The chlorex absorption spectrum in the infrared region is shown in Fig. 3.

The spectrum plot was constructed by consecutive recording of the absorption curve of the empty cell and of the same cell filled with the analyzed substance. The width of the slit was regulated manually. A comparison of the chlorex spectrum with that of dichlorethane indicated that for the analysis under discussion the 8.50 mc absorption band was the most suitable. The calibration curve constructed on the basis of mixtures of chlorex and dichlorethane is shown in Fig. 2. Resins, tars and dissolved rubber produced no appreciable effect on the results of analyses.

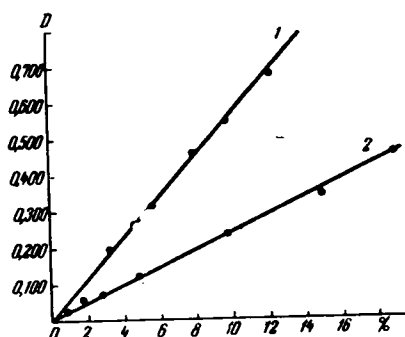


Fig. 2

Fig. 2. Calibrated curves:

- 1 - Absorption in the ultra violet region, λ - 267.5 m μ ;
- 2 - Absorption in the infrared region, λ - 8.50 μ .

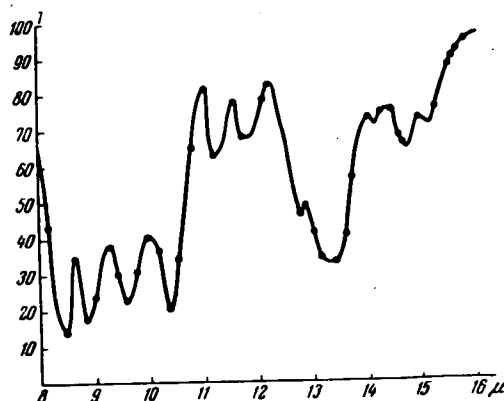


Fig. 3 .

Fig. 3. Chlorex absorption spectrum in infrared region.

T A B L E 2.

Chlorex %		Error %	
Taken	Found	Abso- lute	Rela- tive
9.74	9.72	-0.02	0.20
3.98	3.90	-0.08	2.01
12.48	12.35	-0.13	1.0
7.65	7.75	+0.10	1.31
1.73	1.55	-0.18	10.4
6.02	6.02	0	0
12.96	12.90	-0.06	4.64
7.65	6.90	-0.75	0.98
6.65	6.80	+0.15	2.26
8.50	8.44	-0.06	0.70
4.90	4.92	+0.02	0.41
0.92	0.68	-0.24	26.0
3.81	4.25	+0.44	11.55
3.85	4.47	+0.62	16.1
9.31	9.72	+0.41	4.4

Average relative error 5.5.

In the course of the investigation spectra were obtained of combined dispersion and of absorption in the near infra-red region. Combined dispersion spectra were obtained with the aid of a three-prism glass spectrograph ISP-51 with a single bulb source of light and a standard light filter which brought out the Hg 4358 line, used in eliciting the spectrum. A comparison of the dichlorethane spectrum with that of chlorex, shown in Table 3, indicated that the spectra of combined dispersion, in principle, could be used in the analysis.

A universal monochrometer UM-2 with two lead sulfite photoresistors, type FS-A-1, connected to an unbalanced bridge hookup, was used for the study of chlorex and dichlorethane absorption spectra. Notwithstanding the small

T A B L E 3.

Spectrum of combination dispersed light		
Chlorex	:	Dichlorethane 4
242 cm^{-1} (1)		124 cm^{-1} (5)
295 cm^{-1} (1)		264 cm^{-1} (4)
671 cm^{-1} (10)		301 cm^{-1} (10)
757 cm^{-1} (3)		410 cm^{-1} (5)
792 cm^{-1} (1)		653 cm^{-1} (12)
1219 cm^{-1} (10)		676 cm^{-1} (5)
1258 cm^{-1} (1/2)		753 cm^{-1} (15)
1460 cm^{-1}		881 cm^{-1} (3)
2877 cm^{-1} (2)		943 cm^{-1} (5)
2916 cm^{-1} (2)		991 cm^{-1} (0)
2968 cm^{-1} (7)		1032 cm^{-1} (2)
3017 cm^{-1} (2)		1054 cm^{-1} (3)
		1143 cm^{-1} (1)
		1207 cm^{-1} (5)
		1263 cm^{-1} (2)
		1302 cm^{-1} (6)
		1428 cm^{-1} (5)
		1442 cm^{-1} (4)
		2845 cm^{-1} (2)
		2956 cm^{-1} (10)
		3002 cm^{-1} (6)

dispersing power of the instrument in this particular region of the spectrum, the results obtained, as shown in Fig. 4, were definitely of value to the development of a simplified method of spectral analysis of a mixture of chlorex and of dichlorethane.

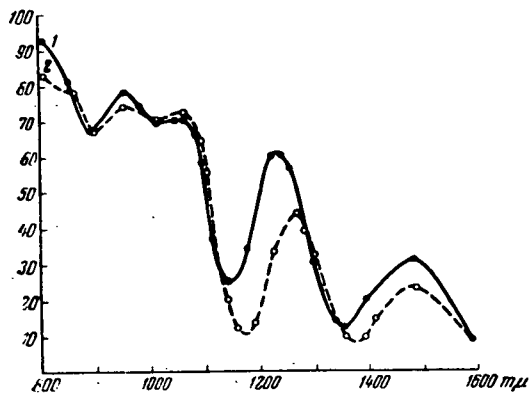


Fig 4. Absorption spectra in the nearest infrared region:

1 - Chlorex; 2 - dichlorethane; pure substances; absorption layer 3.0 cm.

Conclusions.

1. Methods are described for obtaining absorption spectra of chlorex in the ultraviolet, infra-red and the near ultra-red spectral regions and the combined dispersion spectrum.

2. A technique is described for the determination of chlorex in mixture with dichlorethane, based on light absorption in the ultraviolet and infra-red regions.

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Titrimetric Method for the Determination of Ionic Chlorine, Bromine
and Iodine in Mixture.

By

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Zhur. Anal. Khim., Vol. XII, No. 3, 395-397, 1957.

There are two widespread methods for the determination of large quantities of halides in mixtures: the titrimetric and the gravimetric. Beck [1] developed a gravimetric method based on the precipitation of halides by the Ag^+ ion. Freedheim and Meyer [2], following preliminary processing of the solution, determined I^- and Br^- by $\text{Na}_2\text{S}_2\text{O}_3$ titration; the Cl^- ion was precipitated by Ag^+ and then determined gravimetrically.

Berg [3, 4] described a titrimetric method for the determination of the three halides in mixture. The I^- ion was titrated with potassium iodate in the presence of acetone in a solution acidified by H_2SO_4 . The precipitating ion reacting with the acetone formed an iodoacetone. The Br^- and Cl^- ions were determined simultaneously by titration according to Folgard. The Cl^- ion was determined in a separate sample containing Cl^- , Br^- and I^- ; for this purpose ions of I^- and Br^- were oxidized with potassium bromate, and, after binding the free I_2 and Br_2 by acetone the Cl^- ion was determined according to Folgard. In cases of small amounts of Cl^- it was determined nephelometrically. The amount of Br^- was determined by difference. Using this method Mitchel and Ward [3] obtained higher yields for ions I^- and Br^- . Alpine [6] ascribed the higher yield in determining Cl^- to the hydrolysis of bromo- and iodoacetone. According to the data furnished by Berg [4] the loss of Cl^- ion due to oxidation by bromate may range from 2% to 40% depending upon the duration of the reaction and the halide concentration. All the indirect methods mentioned consist of a large number of operations, are complex, time-consuming and are insufficiently accurate [5].

The titrimetric method of R. Berg for the determination of large amounts of halide ions in mixture was improved as the result of experiments carried out by the present author in the direction of simplification, precision and rapidity.

Chlorine, bromine and iodine were determined in one sample. The procedure to be followed in the modified method is as follows: into an Erlenmeyer flask of 100 - 200 ml capacity place 5 or 10 ml of 0.01 or 0.10 N KI solution, 0.02 or 0.10 N KCl solution and 0.20 N KBr solution. Add 15 ml of acetone and 3 to 5 ml of 1:3 colorless H_2SO_4 solution. The iodide concentration in the final solution should be respectively 0.001 or 0.01 N, and the concentration of H_2SO_4 should be respectively 0.8 to 1.3 N. The I^- is titrated with 0.01 or 0.10 N of a KIO_3 solution. The liberated free iodine reacts with the acetone. The solution containing 0.001 N KI becomes colorless intermittently, while the solution containing 0.01 KI retains its color and becomes colorless only toward the end of titration. Further titration should be carried out gradually adding two to three drops of the KIO_3 solution at a time. In both cases the change from yellow to colorless, or vice versa, is very distinct. At the point of equivalent ionic I^- oxidation the solution remains colorless to the last drop of the KIO_3 . To assure full oxidation of the I^- ion, it is enough to add a one or two drop excess of KIO_3 . At H_2SO_4 concentration range of 0.8 to 1.3 N only the I^- ion becomes oxidized, while the Cl^- and Br^- ions remain in the solution.

For the determination of the Br^- ion, 15 ml of 2:1 H_2SO_4 is added to the solution while stirring. The total H_2SO_4 concentration in the solution will be 6.7 - 7.30 N, and the concentration of bromide will be 0.018 N. The solution temperature will rise due to the addition of the H_2SO_4 ; in this warm solution the Br^- ion is determined by titration with an 0.40 N solution of KIO_3 , which is added a drop at a time. Under the above conditions only the Br^- ion becomes oxidized; the latter together with the iodine formed in the process of iodate reduction will turn the solution yellow; this color will rapidly disappear as the result of the reaction between the halogens and the acetone. At the point of equivalent Br^- ion oxidation the last drop of the KIO_3 will no more color the solution. To assure complete oxidation of the Br^- ion, add a one or two drop excess of iodate.

For the determination of the Cl^- ion the solution is cooled to room temperature. The lowest initial chloride concentration which can be determined by titration is 0.0017 N. In solutions of such or higher chloride concentrations the Cl^- ion is determined according to Folgard; at lower concentrations it is determined nephelometrically. Determination results are shown in Tables 1 and 2.

T A B L E 1.

The I^- ion was titrated with 0.01 N KIO_3 solution and Br^- ion
with 0.40 N KIO_3 solution.

Taken in ml			Found in ml		
0.01 N KI	0.20 N KBr	0.20 N KCl	0.01 N KI	0.20 N KBr	0.20 N KCl
5.0	5.0	5.0	4.95	4.90	4.85
5.0	5.0	5.0	5.00	4.92	4.94
5.0	5.0	5.0	5.00	5.00	5.00
10.0	10.0	10.0	9.94	9.95	9.85
10.0	10.0	10.0	10.00	10.00	10.00
10.0	10.0	10.0	10.05	10.00	10.05

T A B L E 2.

The I^- ion was titrated with 0.10 N KIO_3 solution and Br^- ion
with 0.40 N KIO_3 solution.

Taken in ml			Found in ml		
0.10 N KI	0.20 N KBr	0.10 N KCl	0.10 N KI	0.20 N KBr	0.10 N KCl
5.0	5.0	5.0	4.96	5.00	5.09
5.0	5.0	5.0	5.00	5.10	4.98
5.0	5.0	5.0	5.05	5.08	5.10
10.0	10.0	10.0	10.05	9.80	10.14
10.0	10.0	10.0	10.15	10.12	10.01
10.0	10.0	10.0	10.20	10.00	9.91

Conclusions.

1. A titrimetric method was developed for the determination of I^- , Br^- and Cl^- ions simultaneously present in solution. The I^- and Br^- ions are titrated with calcium iodate, Cl^- ion is titrated according to Folgard.

The determination of the three halogens is made in one sample. The determination requires 12 - 15 minutes. The method is simple and accurate.

2. Optimum initial H_2SO_4 concentrations were established for the separate titration of the I^- and Cl_2 ions with potassium iodate.

3. Lowest initial concentrations that can be determined by titration of mixtures of the three were found to be 0.0014 N for I^- , 0.0180 N for Br^- and 0.00170 N for Cl^- .

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Improved Experimental Toxicological Method of Animal Inhalation Exposure.

By

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Farmakologiya i Toksikologiya, Vol. 20, No. 2, 70-73, 1957.

The exposure of laboratory animals to dust inhalation is a basic method employed in the investigation of effects of harmful dusts, gases and vapors on the living organism. Inhalation exposure of test animals is carried out in special chambers such as the dynamic exposure chamber, in which concentrations of harmful substances in the air can be varied automatically in the course of the experiment.

In the existing experimental toxicological practice complete examination of test animals is made before and after the exposure of the animals, that is, before placing them into the exposure chamber and after removing them from it, thereby interrupting the process of the experimental exposure. This constitutes a great shortcoming in present-day toxicological experimentation. Until recently only a most general and cursory examination of the condition and beha-

behavior of the experimental animals was possible without interrupting the active experimental inhalation, i.e., without removing the test animal from the experimental exposure chamber. This was due to the lack of appropriate dynamic toxicological methods and procedures for the intimate observation and recording of changes occurring in the physiological and behavior indexes of the test animals. This was and still is particularly true of the so-called chronic toxicological exposures.

The present article presents an account of a preliminary experiment in improving presently existing experimental toxicological procedures. The method developed enables automatic kymographic recording of changes in respiration, pulse beat, blood pressure, and to obtain vitograms under active exposure conditions, inside the treatment chamber. By the new experimental procedure it was possible to take blood samples from the femoral and common carotid arteries for blood pictures, biochemical and chemical investigations under active conditions of acute intoxication, thereby enabling a more thorough examination of the organism during a prolonged uninterrupted action of harmful substances entering the organism via the respiratory tract.

This procedure may prove of value in the study of pathological and clinical problems and in experimental therapy of acute intoxication caused by highly active paralyzing or lethal poisons.

The following laboratory equipment is employed in the suggested procedure: 1) exhaust hood; 2) set-up for the dynamic exposure of laboratory animals to vapors of the substance under study, or exposure chamber (250 - 500 li capacity); 3) universal stanchion built to order; 4) laboratory animal (medium size dog); 5) kymograph, Ludvig manometer and time recorder; 6) fine rubber tubing and glass connections; 7) Hofman, Moore and Diefenbach clamps; 8) 30% sodium citrate solution (500 ml); 9) set of surgical instruments for exposure of arteries, arterial cannulae, rubber gloves; 10) 30 - 50 ml toxic substance under investigation in a spray apparatus.

With the exception of the universal stanchion, description of the rest of laboratory equipment and of the set of instruments can be found in any handbook of physiology or toxicology.

The universal stanchion consists of a regular wood or metal frame into which the test animal is fixed to maintain a standing position; attachments for the kymographic recording of respiration and blood pressure of the animal are

arranged. The stanchion with the animal in fixed position is then wheeled into the experimental exposure chamber which contains other equipment or apparatus required for performance of the experiments. The stanchion, illustrated by Fig. 1 and Fig. 2, is essentially a modification of the Pavlov frame, and can be built to accommodate work with laboratory animals of any size. Supplemental attachments or contrivances can be introduced for the performance of special studies.

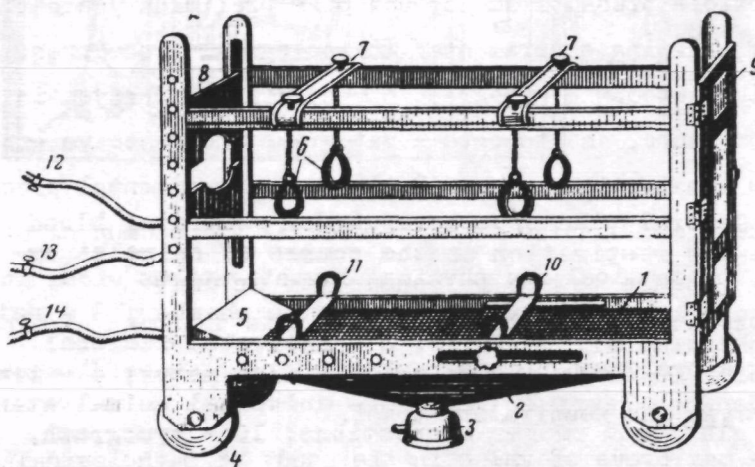


Fig. 1. Universal stand for dogs under study during their (dynamic) exposure to a poisonous gas or dust.

1 - Perforated steel floor for retension of feces;
 2 - steel funnel, connected with 3 - glass urine collector; 4 - moving wheels; 5 - wooden platform connected with device recording movement of front legs;
 6 - rubber cushioned steel chains for holding dogs in place; 7 - upper adjustable frame; 8 - adjustable head holder; 9 - animal entrance door; 10 - adjustable hind leg holder; 11 - adjustable front leg holder; 12 - respiration recording connection; 13 - Ludwig manometer connection; 14 - general actogram connection

The procedure. For kymographic records of respiration and blood pressure under conditions of dynamic exposure to vapors of harmful substances, medium size dogs weighing 6.8 and 10 kg are the most appropriate laboratory animals.

The test animal is secured to the operating table and prepared for the operation; the femoral or carotid artery is bared and the cannula inserted, fastened to the animal's hip with 2 - 3 skin sutures, and the artery shut off with a Diefenbach clamp; the animal is then taken carefully off the operating

table and secured in the universal stanchion in a standing position, as shown in Fig. 2.

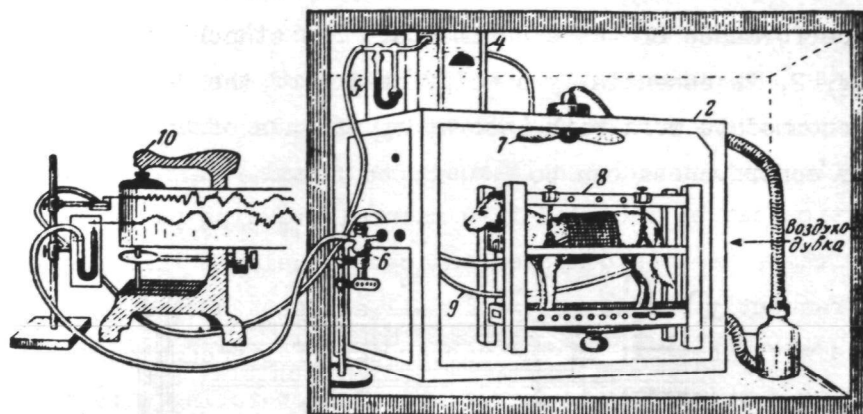


Fig. 2. General plan of apparatus for recording blood pressure and respiration in the course of animals' exposure to the poisonous gas or dust

1 - Exhaust hood and fan; 2 - exposure chamber; 3 - activated charcoal air purifier; 4 - activated charcoal and calcium chloride air drier; 5 - flow meter; 6 - test substance disperser; 7 - fan; 8 - universal animal stand; 9 - glass and rubber connections; 10 - kymograph.

With the help of four iron rings, soldered to the base of the stanchion (the front rings are immobile and the rear ones mobile), the dog's paws are fastened firmly to the base of the stand. In preparing the dog for kymographic recording of respiration and of blood pressure all four legs should be securely fastened, and in preparation for the vitogram record only the rear legs, allowing the front legs to move freely. When the dog is highly irritated, or stimulated, which usually occurs during the reflex period of intoxication by the tested substance, the animal will struggle in an attempt to break loose from the stanchion which will cause the free legs to exert some pressure on the movable disc in the middle part of the stand. The pressure on the disc will transmit itself to the rubber balloon and from it, along a closed air pressure system through narrow rubber tubing to the second "mareevskaii drum"; changes in the latter will be recorded on the kymographic tape. Sharp deflections in the actogram, or vitogram reflect the degree and duration of the animal's agitation. Agitation will be followed by inhibition of the animal's nervous system, and the actogram deflections will become infrequent and of low amplitude.

In addition to fastening the feet to the base of the stand, the test animals are also held by four rubber rings. The dog's body is fastened to the stand with two wide canvas belts at the origin of the front and hind legs. The dog's head remains free during the test. Held in this position the test animal maintains a relatively normal physiological balance when it is calm. The chest movements (inhalation and exhalation) are normal, and the blood circulation and respiration can be recorded in a natural standing position. The dog, fastened to the frame, remains composed and can be held in this position up to 10 - 12 hours; frequently the animal will fall asleep. Recording of respiration movements is done with the help of the rubber cuff fastened around the animal's chest. The cuff is connected by means of fine rubber tubing with the first "mareevskaya kapsul". The blood pressure is recorded via the cannula inserted into the femoral or carotid artery, and connected by means of fine rubber tubing filled with a 30% sodium citrate solution to a graduated Ludvig manometer.

Application of the method during the test. By means of the special universal stanchion it is possible to record respiration, blood pressure and the vitogram or actogram under conditions of dynamic exposure of the animal to vapors of a harmful substance (Fig. 2). The stand with the laboratory animal fastened in it is placed inside the exposure chamber. During the dynamic exposure of animals, air containing known concentrations of the harmful substances is aspirated through the chamber at a constant rate. Special provision is made to prevent the escape of the poison-saturated air into the external air medium. Details of the construction and operation of universal stanchion inside the exposure chamber are shown in Figs. 1 and 2.

[Note: Electrocardiographic studies can be carried out in a similar manner by making appropriate provisions for the extension of the leads and extra connections.]

The tubes connecting the arterial cannula with the Ludvig manometer must be absolutely clean, washed with a 30% sodium citrate solution immediately before the test; they ought to be as short as possible to avoid blood coagulation in the cannula.

Thus prepared, the system is ready for operation. First, a thorough inspection is made of all recording parts of the kymograph and of their connections. The Diefenbach clamp on the artery is then released allowing automatic

recording of blood pressure. Appropriate connections are then made for the recording of the respiratory movements. The door of the treatment chamber is then tightly closed. During 1 - 2 minutes "normal" or "control" records are made. Then, without stopping the movement of the kymograph, the dynamic exposure set-up is plugged in. Vapor of the harmful substance of the desired concentration in air, is aspirated into the exposure chamber. The beginning of the test is marked on the kymograph paper with the letter "D"; for a period of 3 - 5 minutes changes in respiration and blood pressure are recorded in the initial period of reflex intoxication. Following this, one minute records are made at 10, 30, 60 and 90 minutes for 2, 3, 4, 5 and 6 hours; during the intermittent intervals the kymograph is stopped. The duration of the intermittent periods and of the total duration of the experiment should be determined individually for each case under investigation.

The test procedure described is carried out under conditions of forced air current in a specially built exhaust hood. At the end of the test the rubber tubes are disconnected and the stand with the dog in it is taken out of the exposure chamber into the exhaust hood, where it is freed of residual toxic vapor.

Calculating "Physical" Toxicity for the Preliminary Determination of Maximum Permissible Concentrations.

By

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Toxicological Laboratory, State Scientific-Research Institute of Industrial Hygiene and Occupational Diseases.

Gigiena Truda i Prof. Zablev., Vol. 2, No. 2, 41-47, 1958.

New substances are being steadily introduced into the production industry, some of which possess properties deleterious to health. It is imperative that methods be found for the rapid determination of maximum allowable concentrations in the air of such substances before their production and industrial utilization assume extensive proportions. Clinical, statistical and animal experimental data frequently proved inadequate for this purpose. The rapid determination of limits of allowable concentrations of air pollutants should be based on general principles derived from a study of the action of a significant number of different substances. Some of the general principles which determine the properties of organic substances, chiefly volatile organic fluids, are now well known.

In 1944 N. V. Lazarev summarized the information available on the relation between the narcotic potency of organic substances and their physiochemical properties. He presented formulas for the estimation of narcotic concentrations of such substances. Lazarev called the biological action of nonelectrolytes, as determined by their physiochemical properties, nonelectrolytic or non-specific in distinction from the specific action of a poison as a function of its active chemical properties. Similarly, foreign scientists speak of "physical" toxicity, when referring to the nonelectrolytic effect, or of "chemical" toxicity when the poison acts on the organism through special chemical reactions.

Ferguson concluded that concentrations producing identical biological effect (death of insects after several hours) were within relatively narrow limits; his conclusion was based on calculations of the concentration intensity of the deleterious substances present in the animal's environment. Ferguson found this to be true of liquid and gaseous solutions or suspensions. In the case of the gaseous or air phase Ferguson expressed active concentrations as percentages

of gas buoyancy or vapor pressure, and called them "thermodynamic" concentrations.

Results of experimental studies by the Toxicological Laboratory of the Leningrad Institute of Industrial Hygiene and Occupational Diseases established the existence of a relationship between the potency of nonelectrolytes and their physiochemical properties by showing that lethal, narcotic and threshold concentrations, which affected the flexor reflex in rabbits after 40 minutes exposure, varied with solubility of the substance in water and with the distribution ratio between oil and water. Threshold concentrations of various organic substances for rabbits were compared with official maximum permissible concentrations and those determined by this author. Results indicated that where organic solvents have no marked "chemical" toxicity, the ratio between the two series of values fluctuated within comparatively narrow limits. On the basis of the data the following empirical formulas were derived for the presumptive estimation of maximum permissible concentrations of substances with nonelectrolytic action:

$$\log C = 0.92 \log S + \log M - \log \lambda - 3.15 \quad (1)$$

$$\log C = -0.87 \log K + \log M - \log \lambda - 0.35 \quad (2)$$

where S = solubility of the substance in water in millimols per liter;

M = molecular weight;

λ = factor of vapor solubility in water;

K = distribution ratio between oil and water.

Data derived from formulas (1) and (2) are expressed in milligrams per liter.

In 1955 MacGowan proposed two other formulas for the determination of maximum permissible concentrations of substances free from "chemical" toxicity.

For preliminary estimation MacGowan used formulas he advanced for the computations of average lethal concentrations of insecticides and dividing the final result by 25, or by subtracting 1.4 from the logarithm of the concentrations.

$$\log C = (3.12 + \log P - \log L + 0.001\pi) - 1.4 \quad (3)$$

where C = maximum permissible concentration;

P = vapor pressure in mm mercury;

L = a fraction, the numerator of which is the density (in practice the specific gravity) multiplied by 1000, and the denominator is equal

to the molecular weight;

π = parachor (a constant related to molecular volume).

MacGowan introduced additional values for the computation of 0.0014π .

It is pointed out that this formula was derived on the basis of an assumption of equal thermodynamic poison effects of "physically" toxic substances. The formula is based on extensive experimental data and is useful for the calculation of the toxicity of vaporized liquids.

MacGowan's second formula is a simple one:

$$\log C = \sum f - 1.4 \quad (4)$$

The total of factors ($\sum f$) is taken from a special table of $\sum f$ values for ethane, cyclohexane, benzene and naphthalene. Corrections in the totals are introduced where definite groups consisting of carbon and hydrogen elements are substituted by groups which contain different numbers of carbon and hydrogen atoms, and those in which hydrogen was replaced by Cl, NO₂, CH₃, CN and other groups. By the gradual substitution of groups most closely simulating the external structural formula by other suitable groups it is possible to arrive at homologues; in the course of this process values corresponding to each substitution are added to or subtracted from the original total of factors, $\sum f$.

The calculation is simple and is based on the knowledge of the structural formula of the substance. Factors for the original compounds and the corrections are obtained experimentally. It has been established that each succeeding member of a homologous series is two to three times more toxic than the preceding member. Accordingly, substitution of C-CH₃CH for the CH group decreases the logarithm of the sum of the factors by 0.34, which is equivalent to the division of the toxic concentration by 2.2. Toxicity intensification by substituting CCl for the CH group, according to this Table, requires that the concentration logarithm be decreased by 0.74 or the absolute concentration divided by 5.5, etc. Both MacGowan's formulas yield results in parts per million.

For the evaluation of the different methods of calculating maximum permissible concentrations, the values derived were compared with the maximum permissible concentrations fixed by law or suggested by Soviet industrial toxicologists. This was done for 53 organic substances. In addition to checking the above four formulas, calculations were made on the basis of average threshold concentrations for rabbits, divided by ten:

Limits of logarithmic deviations of calculated concentrations from those adopted or proposed in the USSR												Number of substances	
	-1.40-1.79	-1.00-1.39	-0.60-0.99	-0.20-0.59	0.20-0.19	0.60-0.21	1.00-0.61	1.40-1.01	1.8-1.41	2.20-1.81	2.60-2.21		
According to formula 1	—	—	4 10	7 20	16 42	6 17	2 5	0	1 3	—	—	16	
According to formula 2	—	—	1 5	4 18	10 45	6 27	1 5	—	—	—	—	22	
Acc'g to form. 3 (-1.1)	1	0	4 8	10 20	15 30	9 18	5 10	2 4	3 6	0 —	1 2	30	
Acc'g to form. 4 (-1.1)	—	1 2.5	1 2.5	9 24	14 37	5 13	5 13	1 2.5	2 5.5	—	—	38	
Acc'g to exptl. formula (-0.1)	—	—	1 2	7 17	21 51	10 24.5	1 2.5	0	1 2.5	—	—	41	

Number of substances concn. of which fell into some deviation group

$$\log C = \log C_1 - 1 \quad (5)$$

where C = maximum permissible concentration;

C₁ = average threshold concentration using flexor reflex reaction effects in rabbits, after a 40-minute exposure, as the indicator.

Hence, formula (5) is based not on physiochemical constants, but on experimental data.

Fig. 1 presents distribution curves of logarithm deviations of calculated concentrations from the logarithms of U.S.S.R. regulatory concentrations. The curves also show that according to MacGowan's formulas the limits of allowable concentrations for most substances were too high. However, the point of importance in this case is not the poor correlation between the calculated values and the physical toxicity of the substances, but the excessively high limits of permissible concentrations in U.S. industries. It is only natural that MacGowan's formulas should cover a range of maximum allowable concentrations accepted in the United States and not in the U.S.S.R. For our purposes it is important that there be a good correlation with physical toxicity; correction factors for lowering the concentrations can be easily introduced.

Correlation coefficients calculated for values derived from different for-

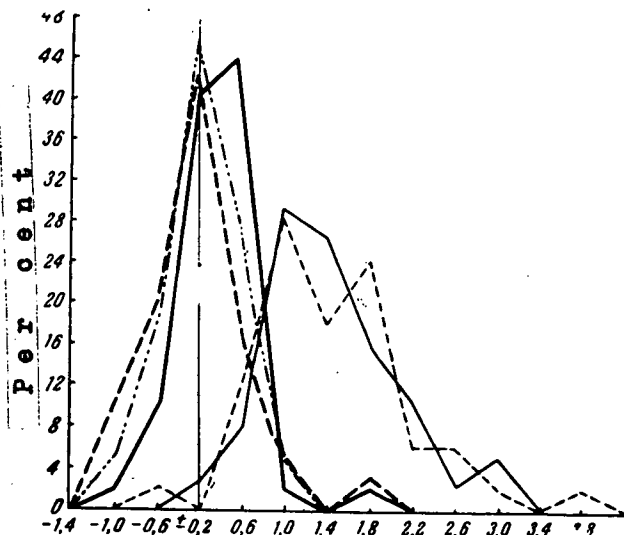


Fig. 1. Distribution curves of limits of allowable concentration deviations arrived at by different methods from those adopted by or proposed to the U. S. S. R.

Solid line - distribution of experimental concentration deviations; heavy dash line - based on solubility in water; light dash line - based on coefficient of distribution between oil and water; dash and dots line - according to MacGowan's simple formula; solid fine line - according to MacGowan's complex formula

mulas in relation to adopted limits of allowable concentrations, yielded the highest correlation (82%) with values obtained experimentally. Calculations based on the coefficient of distribution between oil and water and on MacGowan's complex formula, yielded a correlation of 68%. Solubility in water, according to our calculations, was 60%; according to MacGowan's simple formula, it was only 41%. The curves in Fig. 1 show that the spread of data calculated by the American formulas was considerably greater than of the data calculated according to our formulas.

The value distribution curve derived from threshold concentrations for rabbits has a median tending toward overestimation. In determining the correlation of such data with adopted U.S.S.R. limits of allowable concentrations and in deriving the correlation equations the need to decrease the values by subtracting not 1 but 1.1 from the concentration logarithm became apparent. If the values obtained from MacGowan's formulas are to be brought into closer agreement with the Soviet maximum permissible concentrations, their logarithms must be reduced by at least 1.1. MacGowan's formula $\log C = \sum f - 1.4$ will then appear as:

$$\log C = \sum f - 2.5$$

The limits of allowable concentrations established in the U.S. are based on the assumption that it was safe to work at a pollutant concentration 1/25th of the one lethal for insects. In the U.S.S.R., the lethal concentration for

insects must be divided not by 25, but by 316 the antilog of 1.4 being 25 and of 2.5 - 316.

Fig. 2 presents distribution curves obtained after making appropriate corrections, i.e., after subtracting 0.1 from formula (5) and 2.5 instead of 1.4 from MacGowan's formulas (3) and (4). Following such corrections the distribution curves fell more in line with the maximum of data for each curve with a deviation of ± 0.2 . The greater part of the data calculated according to each formula were within ± 0.6 of the logarithm of the maximum permissible concentration required by the Soviet regulation or within a range of values 4 times higher or lower.

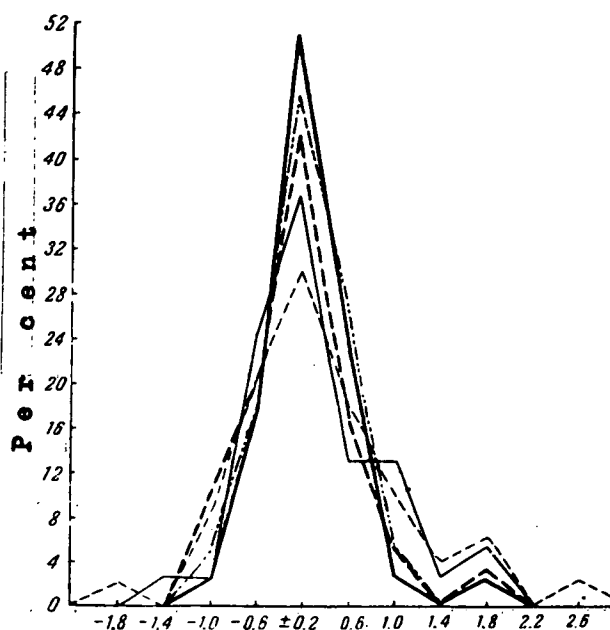


Fig. 2. Distribution curves of limits of allowable concentrations deviations arrived at by different methods from those adopted by or proposed to the U. S. S. R., after the introduction of corrections as indicated in the text
(Rest of legend is the same as in Fig. 1)

tions for aldehydes were not calculated by MacGowan's second formula for lack of certain constants. Results of calculations by this would place vinyl butyrate, vinyl propionate and vinyl acetate, i.e., irritants with marked chemical activity and "chemical" toxicity at the extreme right end of the list.

It was not possible to calculate the maximum permissible concentrations for aldehydes either by their solubility in water or by the ratio of distribu-

Most overestimated values according to MacGowan's simple formula were obtained for the following chemical compounds: formaldehyde, acetaldehyde, propionic aldehyde, vinyl acetate, butylaldehyde, and vinylidenedichloride. All these substances have strong irritating effects related to their chemical activity, and it is not surprising that a formula, based on the assumption that a substance possessed only "physical" toxicity, should yield incongruent values. The maximum permissible concentra-

tion between oil and water because the coefficients of their fume solubility in water, necessary for such calculations, were not known. Van Ventyan obtained experimental data for formaldehyde and butylaldehyde. Values obtained for both substances had a deviation range of ± 0.2 .

Lowest deviations were obtained in calculations based on results of experiments with effects of vapor threshold concentrations of the flexor reflex response in rabbits. Only for 2 or 41 poisons (methyl alcohol and cyclohexanone) did the calculations yield fourfold overestimated concentrations.

The specific action of methyl alcohol caused by its chemical transformations in the organism is well understood. In addition vapor of methyl alcohol, like vapor of cyclohexanone, is highly soluble in water and slowly saturates the organism upon inhalation. The action of these substances is augmented by increase in concentration and by exposure time. Naturally, correct results cannot be obtained for such poisons with 40-minute exposure tests as the basis. The data of A. P. Voronin derived from 8-hour experiments on rabbits were taken as indexes of threshold concentrations. If the threshold concentrations of cyclohexanone at 8-hour exposure are taken as the basis, the maximum permissible concentration of cyclohexanone will be only twice the one proposed by the writer on the basis of his experimental results. It can be concluded that all the formulas cited were generally useful for the preliminary estimate of limits of allowable concentrations of substances free from marked "chemical" toxicity, and that appropriate correction factors must be introduced into MacGowan's formulas. The fact that MacGowan's simple formula produced the highest deviations must also be kept in mind. For "chemically" toxic substances calculation by the formulas determined upper limits; maximum allowable concentrations should be established at levels below such upper limits.

In practice it is useful to make preliminary determinations of maximum permissible concentrations by all methods applicable to each specific case. Since limits of allowable concentrations were established for a comparatively small number of harmful organic substances, preliminary calculation of an approximate maximum concentration would be valuable for newly introduced substances as well as for substances currently employed in industry but little investigated.

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Determination of the Direct and Indirect Effects of Pharmacological Preparations on the Blood Vessels.

By

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Farmakologiya i Toksikologiya, Vol. 21, No. 3, 78-81, 1958.

In measuring the resistance of blood vessels by the method of minute by minute autoperfusion by regulated blood volumes, there appear two conditions which make it possible to immediately determine the nature of the direct or indirect effect of pharmacological preparations on the vessels of any organ.¹

The determination of the blood vessel resistance is based on the following principle (Fig. 1). A perfusion pump (a - d), equipped with outside electromagnetic valves (e', e'') draws blood from the central end of the artery (f),

¹ By direct effect is meant the change in tonus of the vessels of an organ due to the action of a substance within the given organ, i.e., on the smooth muscles of its vessels, or on the elements of the peripheral nervous system found therein. By indirect effect is meant the change in the lumen of the vessels due to the action of the substance on the elements of the nervous system found outside the organ in question, or due to reflex reactions to the vessels of this organ arising after the introduction of the given substance.

which supplies the given organ, and forces it into the peripheral end of the same artery (g) in constant minute by minute amounts. Constriction of the vessels forces part of the blood into a manometer (h), the pressure between the outflow valve of the pump (e'') and the vessels of the organ rises, reaching a new level needed to pass the desired minute by minute constant amount of blood through the constricted vessels. Contrariwise, when the vessels are dilated, their resistance to the blood flow falls and consequently the pressure caused by the minute to minute constant blood flow through the organ also falls. Variations in pressure are proportional to the type and degree of change in the vessel lumen and, therefore, to the resistance by the blood vessel to the blood flow.

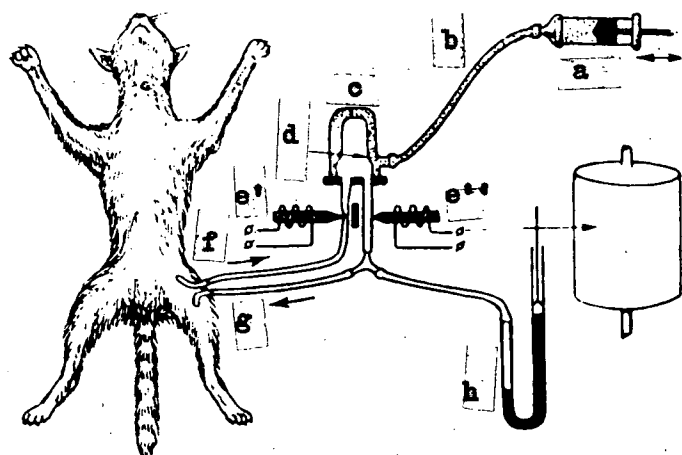


Fig. 1. Plan illustrating the determination of vascular resistance by the autoperfusion method on the minute interval basis.

a - Syringe; b - rigid connecting tube; c - pumphead chamber; d - an elastic "finger valve" which separates the working liquid (water) from the blood; e' and e'' - outside electromagnetic valves; f and g - cannulas inserted into the central and peripheral arterial termini; h - mercury manometer.

The apparatus here proposed was described in 1957 by V. M. Khayutin, V. M. Danchakov and V. L. Tsaturov. In this apparatus use is made of independently regulated electromagnetic valves which separate the organ vessels from the animal's arterial system and the use of a constant water-drive system. The construction of the apparatus is such that the minute-by-minute discharge of blood and perfusion pressure remain constant despite fluctuations in the animal's arterial pressure.

This is the first condition which makes possible the differential observation of the direct and indirect effects of pharmacological preparations on the vessels of an organ under study. The second condition is created by incorporating into the arterial system of the organ an auxiliary artificial circulatory system consisting of cannulas, connecting tubes, and elastic "finger" of the perfusion pump, (Fig. 1d). Accordingly, to the blood circulation time T (e.g., from the femoral vein to the arterioles of the organ under study) additional time t is added, equal to the time required for the blood to pass through the artificial system. Time t can be determined by dividing the amount of blood contained in the system (V ml) by the volume of the blood per second (Q ml/sec) forced through by the perfusion pump:

$$\frac{V \text{ ml}}{Q \text{ ml/sec}} = t \text{ sec}$$

Take for example the effect of intravenous injection of adrenalin. It enters into the arterioles of the major circle causing their constriction and increasing the cardiac output per minute. The result is a rise in the arterial blood pressure. As noted above, such pressure has no direct effect on the perfusion pressure; therefore, it remains unchanged at first. It begins to rise only after a lapse of time equal to T + t, i.e., only after the adrenalin has entered the vessels of the organ. The marked time interval between changes in the arterial and perfusion pressures is the manifestation of the direct effect of the substance in question. This is confirmed by the kymogram shown in Fig. 2a which is a record of the reactions of the arterial pressure and of the pressure of the hind leg vessels of a cat after intravenous adrenalin injection. The interval between the pressor reaction of the arterial pressure and the beginning of leg vessels constriction, as revealed by a rise in the perfusion pressure, equalled 22 seconds. With a blood inflow of about 18 ml per minute, (as roughly determined from the scale on the pump) and pulse beats of 120 per minute, the amount of blood perfused is 0.3 ml per second. In this case the capacity of the perfusion system was about 6 ml. Consequently, the adrenalin could not reach the vessels of the leg earlier than 6 ml: 0.3 ml/sec - 20 seconds.

This statement applies only if the substance under investigation cannot get into the vessels except through the perfusion pump, i.e., through the collateral vessels. Different time relations develop between the reactions of

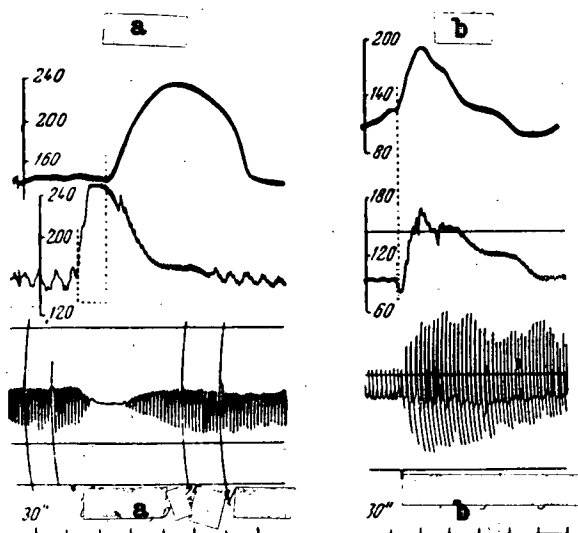


Fig. 2. Cat's hind leg vascular reaction to the intrajugular injection of (a) 25 mg/kg of adrenalin and (b) 4 mg/kg of nicotine. Records from top down: perfusion pressure in the carotid artery (mercury manometer; zero (base) line of perfusion and arterial pressure; respiration mark showing the injection of test substance intrajugularly; time-30 sec. Dotted line - latent reaction period.

arterial and perfusion pressures in instances where the injected substance affected the central nervous system or the elements of the peripheral nervous system outside the perfused organ.

Fig. 2b is a record of the effects noted after intravenous injection of nicotine. The pressor reactions of arterial and perfusion pressure occur almost simultaneously due to the well known stimulation of the sympathetic

ganglion by nicotine. a and b of Fig. 3 illustrate the time correlations following the injection of vasodilators papaverine and tetamon.

In the first instance vascular dilation in the extremity began 9 seconds after the arterial pressure fell; in the second instance the reactions occurred simultaneously. The capacity of the perfusion system in these experiments was 3 ml, which at a rate of blood flow of 0.4 ml per second, delayed the entrance of the substance into the extremity vessel by 7 1/2 seconds. Such delay didn't appear when ganglioblocking tetamon was used; it appeared after the injection of papaverine, which acts directly on the vessels.

Fig. 4 presents a record of the reactions to adrenalin, substantially different from those shown in a of Fig. 2. The perfusion pressure fell the moment the arterial pressure rose; but not as a result of the direct effect of adrenalin on the vessels of the extremity. The vasoconstriction phase actually began 28 seconds after the injection of the adrenalin (perfusion system capacity 6 ml). Evidently the initial dilatation phase was due to the reflex elicited by the rise in the arterial pressure, or to some other effects of adrenalin on elements

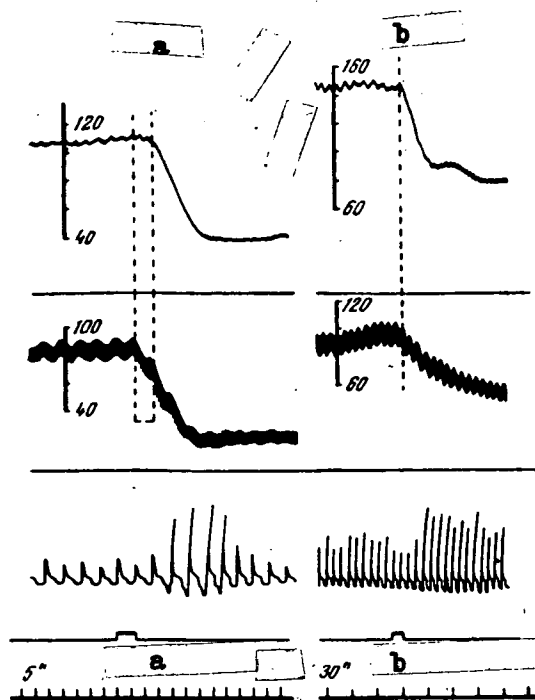


Fig. 3. Cat's hind leg vascular reaction to intrajugular injection of (a) 2 mg/kg of papaverin, and (b) 5 mg/kg of tetamone. Records from top down same as in Fig. 2.

blood vessels. The latter may be determined exactly by enlarging the capacity of the perfusion system. The principal merit of the method is that it permits to differentiate between the hemodynamic and strictly vascular factors which determine the level of blood supplied to the organs.

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of the nervous system located outside the perfused extremity. The experiments of Dörner (1956) and of several others were more in line with the first possibility.

Thus, by registering the resistance of vessels in autoperfusion tests as here-in described, it was possible to make a quantitative evaluation of the degree to which the resistance of vessels changed after the action of pharmacological agents, as well as to elucidate the direct and indirect effects of the preparations on the

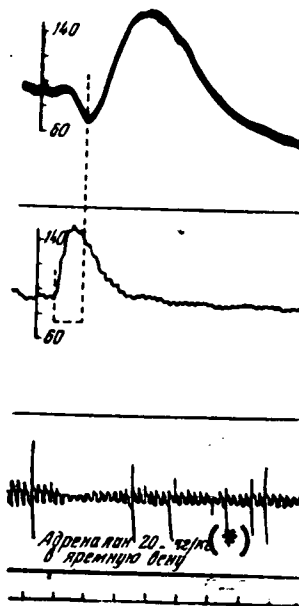


Fig. 4. Two-phase cat's hind leg vascular reaction to intrajugular injection of 20 mg/kg of adrenalin. First phase is indirect, second phase is direct vascular adrenalin effect.

Records from top down same as in Fig. 2.

(*) 20 mg/kg of adrenalin intrajugularly

An Apparatus for the Determination of Dispersed Polyelemental Air Pollution.

By

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Lab. Delo, Vol. 3, No. 1, 47-48.

The air of populated areas may be polluted by dust, gases and microorganisms. Prior to proposing measures for the prevention of air pollution it is necessary to determine the degree and the deleterious effects of the pollution. Many methods have been proposed and are now in use for the determination of the degree of pollution with inorganic substances and for the determination of microorganisms in the air; however, none of the methods have been completely satisfactory. The colorimetric method using Petri dishes and solid media fails to register the degree of air pollution at the very time of the experiment; furthermore, the developed bacterial colonies do not present the true air pollution picture, since the open surface of the dish is in a stationary position in relation to air current changes caused by turbulent conditions.

The apparatus herein described allows the simultaneous collection of air samples for the determination of air dustiness, configuration and chemical composition of the dust particles and for the identification of the microbial population. It consists of four parts: a collecting chamber with two microscope slides forming an angle of 90° for the quantitative, morphological, and qualitative chemical analyses of the particles; depressions at an angle of 45° to hold Petri dishes with appropriate media for the study of the airborne microorganisms; a wind vane which keeps the open part of the collecting chamber and the Petri dishes exposed to the blowing wind, and a supporting stand.

The apparatus can be used under all conditions. It requires no source of power for its operation, it is portable and can be used under complicated conditions of atmospheric air investigations of inclosed spaces.

The apparatus was used in the study of the degree of pollution and the bacterial population of atmospheric air under a variety of conditions at temperatures as low as -40° and as high as $+50^{\circ}$.

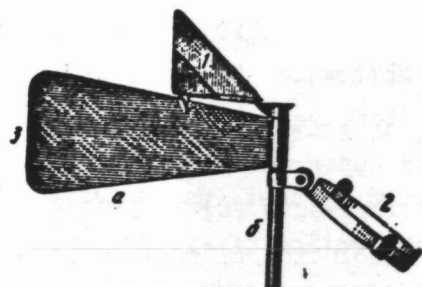


Fig. 1. Assembly side view
(Support not shown)
1 - Trapping device; 2 - Petri dish holder; 3 - wind vane device: a - vane wing; b hollow tube fitting over support rod

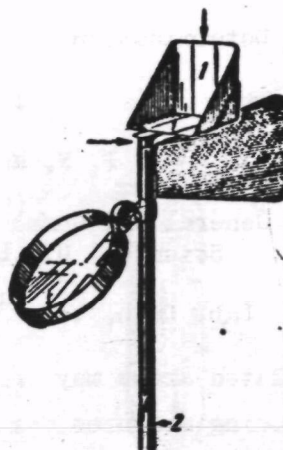


Fig. 2. Swinging part of assembly at 3/4 turn. Support not shown
1 - Holders for grease covered microscope slides; 2 - hollow tube, fitting over support rod

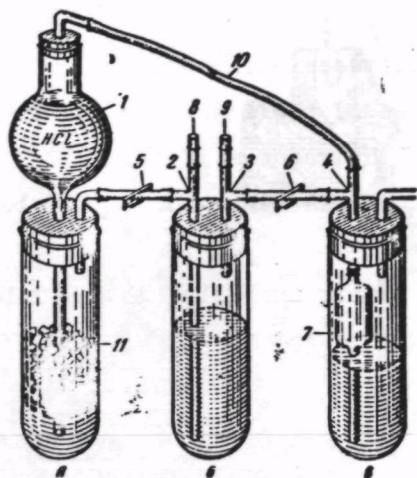
An Apparatus for Work with Hydrogen Sulfide in the Open.

By

V. P. Mikhailov.

Lab. Delo, Vol. 4, No. 3, 55-56, 1958.

In laboratory procedures such as the determination of vitamin C, the quantitative separation of metals, etc., hydrogen sulfide is used as the basic test reagent. The Kipp apparatus used in such cases is bulky, costly to operate and the H_2S must be generated under a hood. This author developed an H_2S generator which can be operated on the laboratory table without the use of a hood.



Apparatus for work with hydrogen sulfide in the open.

The unit is assembled as shown in the drawing. It consists of three heavy-walled test tubes (A, B, C) 2 - 2.5 cm in diameter; a calcium chloride tube (1), glass T-joints (2, 3, 4), screw type clamps (5, 6), Mohr pipette (7) which is shortened at both ends, rubber stoppers and connection tubes.

The apparatus is operated as follows: the absorber tube (C) is filled with a 20 - 30% solution of caustic soda; small pieces of iron sulfide are placed into gas generator (A) over a rubber fitting (11); it is then gradually lowered to the bottom of the generator tube. The fitting can be made of a rubber stopper having two or three notches along its circumference. Clamp (5) is tightened and tube (3) is $\frac{2}{3}$ filled with dilute hydrochloric acid; the top opening of tube (1) is immediately closed with a tightly fitting rubber stopper through which tube (10) passes, thereby connecting tube (1) with tubes A, B, and C through T-joint (4), as shown in the drawing. The test liquid, through which the H_2S is to pass, is poured into test tube (B). At this point openings (8, 9) of T-joints (2, 3) must be sealed by clamps or glass rods. The flow rate of hydrogen sulfide can be controlled with the aid of a screw clamp (5). Excess of the generated gas forces the HCl back into the calcium chloride tube (1), thus decelerating or stopping further gas generation; isolated H_2S bubbles formed in tube (1) from fine fragments of iron sulfide carried into the tube with the rising acid, pass through tube (10) into the alkali containing absorber.

Hydrogen sulfide remaining in the analyzed liquid is forced out by carbon dioxide coming in through tube (8) from a separate CO_2 generator or some other suitable source. Prior to this, clamp (5) must be securely tightened to completely stop any further flow of H_2S . To ascertain that H_2S was completely replaced by the CO_2 the clamp at (9) is released very cautiously and a lead acetate moistened filter paper brought close to it to test for the presence of H_2S ; if the hydrogen sulfide has been removed completely the paper will show no color formation.

Clamps (5, 6) should be tightly closed when test tubes with the analyzed

liquid are replaced or the charged unit is stored between analyses.

If all connections are airtight and the changes of the absorbing alkali solution are well timed, there will be no escape of hydrogen sulfide.

The removal of spent reagents and washing of the gas generator should be done outside of the laboratory.

The proposed unit is simple in construction, easily installed in any laboratory and can be used in routine or training work.

A Continuously Operating Stationary Water Aspirator.

By

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Gigiena i Sanitariya, Vol. 23, No. 12, 69-71, 1958.

Sulfurous anhydride is an important sanitary-hygienic atmospheric air pollutant. This laboratory had the task of determining the presence of SO_2 in the air surrounding large railroad terminals of Bulgaria.

Investigations of sulfurous anhydride require the aspiration of relatively large volumes of air. To obtain a correct picture of the average daily concentration of sulfurous anhydride it is necessary to sample the air continuously over a 24-hour period, or at definite time intervals. This can be accomplished only with the aid of an appropriately designed aspirator. The common water aspirators of 5 - 10 li capacity were found unsuitable for this investigation due to their small volume capacity which required three work shifts for their operation. For the present investigation a stationary water aspirator was needed which provided uninterrupted air aspiration at a steady rate without requiring constant human attendance; its installation, operation, and servicing had to be simple and easy and the apparatus had to be of a wide range of versatility.

In designing a new aspirator, consideration was given to the following: it is known that changes in the height of the water column determined the rate of water flow. Therefore, it was necessary to provide a constant hydrographic pressure under constant conditions to obtain a water stream flow of a constant rate. The new aspirator shown in Fig. 1 consists of the following parts: a 5 - 10 li capacity cylindrical vessel labeled 3, with metallic pipes of 10 mm diameter, labeled 2, 8 and 9, attached to it. Pipe labeled 8 is connected to a water supply faucet by means of a rubber pipe of same diameter, through which water continuously flows into vessel 3. Pipe 9 is connected with a hydrostatic pump, 10, through which the water is discharged. Overflow pipe 2 extends 5 - 8 cm short of the level of the vessel and serves for elimination of excess water. The water inflow rate is slightly greater than the outflow rate which helps to maintain a water column at a constant level. This assures a constant hydrostatic pressure for the operation of the pump which, as a consequence, aspirates the air at a constant rate. To compensate for any lessening or stoppage of the water flow, a simple automatically recording installation is attached to the aspirator. A float 4 is placed in vessel 3. The float is provided with an axis 5, shaped as seen in Fig. 1. The axis terminates with a stylus 6 which records on a bearer 7. The automatic recording device operates as follows: when the water column is maintained at a constant level, float 4 remains on the water surface. The stylus registers this initial position on paper placed over the bearer. Any reduction in the rate of the water flow or its stoppage lowers the water level in tank 3 and causes the float to drop down, which is recorded by the stylus on the paper as a straight line. This registers the stoppage of water flow. Pipe 9 extends 5 cm above the bottom of tank 3, so that the water in the tank retains that level when the water flow stops; this is recorded by the float. If pipe 9 had terminated flush with the bottom of tank 3, the water would flow out without being automatically recorded. To account not only for the stoppage of the water flow, but also for the duration of such stoppage, it is essential that the stylus retain its recording contact with a drum revolving around its axis over a 24-hour period.

The aspirator is calibrated as follows: the aspirator is set into operation, i.e., the water level reaches the level of overflow pipe 2 (Fig. 1) and excess water flows out through it. The order of connecting the installation when air samples are taken is shown in Fig. 2.

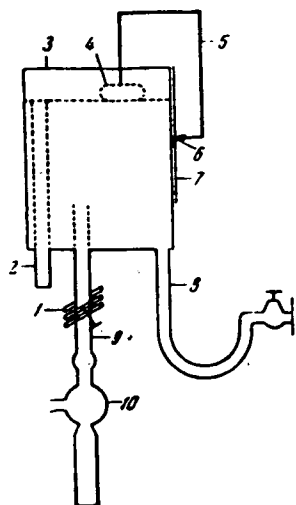


Fig 1. Stationary continuously operating water aspirator.

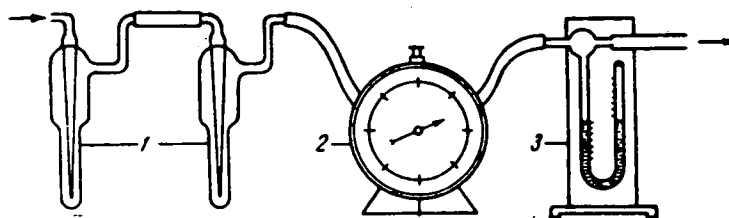


Fig. 2. Scheme of sample collector setup

Aspirated air passes through absorbers 1 (in this case two successively connected absorbers) charged with 5 ml of 5% KClO_3 solution; the air passes through the flowmeter 2 which determines the volume of aspirated air, and through water manometer 3, which measures the pressure drop. The speed of the air current is regulated by means of clamp 1 shown in Fig. 1. For more precise calibration the rate of air flow is measured with a flowmeter as shown in Fig. 2 for a period of 5 - 6 hours. The volume of air is calculated on the basis of the gas meter reading. The volume of air passed through the gas meter is divided by the time of aspiration, giving the rate of air flow expressed in liters per hour or per minute. After that the flowmeter is removed. The pressure drop of the air flow is regulated with the help of a manometer after which, as in the case of gas meter calibration, the manometer is also removed. This concludes the calibration process.

The aspirator runs uninterruptedly. The absorber should be recharged with fresh absorbing solution once every 24 hours, an operation which takes 5 - 10 minutes. Depending on the character of the investigation recharging of absorbers can be done every 2 - 3 hours, which facilitates the carrying out of dynamic investigations. Usually the aspirator is installed on premises fitted out with water supply and canalization (sewer system). This prevents freezing of the aspirator in the winter. Suction of atmospheric air for investigation is done through an air probe. For this purpose rubber or glass pipes with a 10 mm diameter were used. Knowing the time of aspiration, it is easy to find the volume of air passing through the absorbing solution. The absorbing solution is poured into the test tubes, the absorbers are washed several times with distilled water, recharged with the absorbing solution and then attached to the

aspirator for future studies. The aspirator is presently widely utilized in practice and yields reliable results.

Conclusions.

1. The stationary continuously operating water aspirator described is applicable to sanitary-hygienic investigations of air polluted with gases, mainly with sulfurous anhydride.
2. The aspirator permits carrying out of dynamic investigations without requiring continuous presence of a human observer.
3. The aspirator is easy to install and to service.
4. The water consumption does not exceed more than 10 times the volume of the aspirated air.

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A Device for the Evaluation of the Dust Collecting Property of Wetting Agents.

By

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Gigiena i Sanitariya, Vol. 23, No. 12, 71-74, 1958.

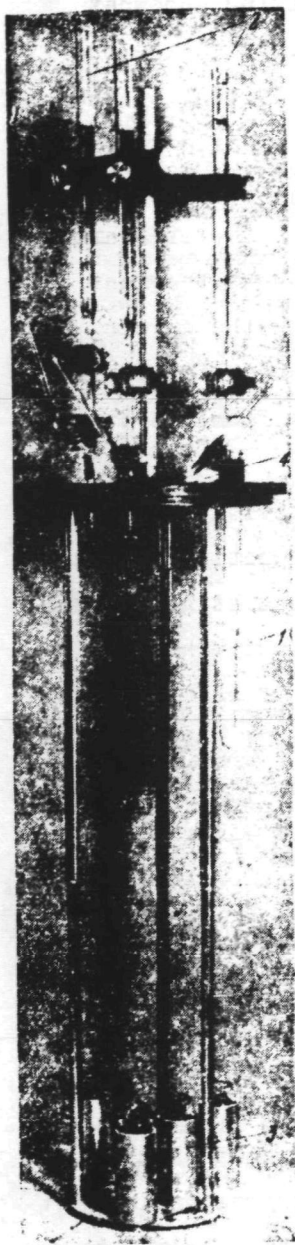
Results of physiochemical investigations of wetting agents used in the abatement of silicosis-causing dusts indicated that the fundamental mechanism of their dust-collecting action was based on physiochemical laws. The effectiveness of their action was found to be specifically connected with the molecular structure of the colloidal-chemical characteristics of the surface active sub-

stances. This makes the experimental evaluation of the properties of water solutions of wetting agents more important and interesting. In this connection the increasing production of synthetic surface-active substances offers the possibility of their wide use in the next years for the control of silicosis-causing dusts as cheap and easily obtainable wetting agents. Under such conditions the utilization of wetting agents represents one of the simplest and highly effective means for the increase of dust collecting properties of water used in drilling blast holes or in bringing down air-suspended dust. In this paper a device is described for the evaluation of the effectiveness of dust collecting properties of wetting solutions. This device is in effect an improvement of an apparatus formerly used in the Institute of Physical Chemistry of the Academy of Sciences, U.S.S.R.; with the present device reliable and easily reproducible results can be easily obtained. The principle of the device is the same as of a water spray wet scrubber.

In the studies here described dust collecting with water and with wetting solution sprays was done simultaneously in air having the same degree of dust concentration. Such a procedure made reproducibility of results easier and more precise. In addition it enabled a more precise comparative nephelometric evaluation of the dust sedimentation results obtained by water spray and wetting agent solutions.

It is important to note that "static" conditions of aerosols formation in the absence of air currents insure a uniform distribution of dust particle clouds throughout the entire dust chamber and at the same time make possible the fractional determination of polydispersed dust within the device. The desired degree of dispersion can be attained and regulated on the basis of precipitation time calculated by Stokes formula (on the assumption that the particles were spherical) and the subsequent checking of particle size microscopically. Such fractional dust determination obviates any effect of dust "age" or its tendency to agglomerate, etc.

The device (see picture) consists of a dust chamber which has a diffuser (1), three burettes - one for water and two for the wetting solution (2), and small beakers (3), one of which is for the collection of freely (normally) precipitating dust. The beakers are placed on a platform suspended from the cover of the chamber (4) and are covered with metallic lids; with the help of



an electromagnet, placed outside the device, the lids can be removed before the start of the tests.

The dust chamber is a large bottomless cylinder having a diameter of about 25 cm, a height of about 60 cm and a volume of approximately 25 - 30 li. An ebonite cover fitted with a rubber gasket to an ebonite ring, placed on the upper part of the cylinder, hermetically closes it and prevents the dust from escaping into the atmosphere and diverts it through a special pipe into the exhaust ventilation.

The diffuser, in the shape of a bent tube 10 - 12 mm in diameter, is set into a rubber stopper in the covering of the device. A weighed amount of dust (0.1 - 0.2 g) is placed into the straight part of the tube which is connected with the air under 0.3 - 0.4 atm. pressure. Inside the diffuser are projections which diffuse the dust uniformly without "spilling".

The dust is first dried at $105 - 100^{\circ}$, sifted through a 5000 - 6000 mesh sieve and is kept in closed boxes in a desiccator. To prevent moisture from entering the device and to prevent dust particles from adhering to each other, the air is dried in a 50 cm long calcium chloride tube before it enters the diffusion tube.

Burettes for the water and for the wetting solution, of 25 mm capacity, are placed into special holders attached to the cover of the device in such a way that their lower parts protrude 8 - 10 mm into the chamber. Each burette is fitted with one ordinary and one micro stopcock which permit formation of droplets of a wide range of sizes.

The distance which the droplets fall must be not less than 40 - 50 cm to enable them to gather a sufficient quantity of dust particles. In the lower part of the dust chamber, on a special platform suspended from the cover (4), glass receptacles are placed for the collection of the dust and droplets. For this purpose it is convenient to utilize standard 22 - 25 ml capacity penicillin flasks, having a 12 - 14 mm diameter at the top. With a greater diameter a greater quantity of free precipitating dust enters the receptacle, thus increas-

ing the magnitude of the correction factor (see below) and lowering somewhat the precision of the determination values. As mentioned above, to reduce the quantity of free (spontaneously) precipitating dust during the dusting of the chamber, the collecting glasses are kept covered with light lids while the dust is admitted into the chamber. The lids are joined so that both can be lifted or placed in position in one operation. Before the test begins, the lids are automatically removed with the aid of an electromagnet. To prevent the dust collected on the lids from falling inside the collecting glasses the covers are fitted with a flange covered with a thin layer of glue. The device is installed in a true vertical position so that droplets separating from the tips of the burettes fall through the neck to the receptacles.

With this device evaluations can be made of the general effectiveness of the wetting agents in relation to droplet size, the hydrophilic action of their adsorption layers, as well as the adsorption effect alone by separating it from the total effect. For the comparative study of the general effectiveness of the wetting solution use is made of equal volumes of water and of wetting solution, working with capillary pipettes having tip openings of equal diameter, so that the number of droplets of water and of solution is different due to differences in their surface tension. For the determination of the adsorption effect alone use is made of burettes with different cross-section tips so chosen that the droplets of water and of the wetting solution are equal in size.

It is easy to select the right opening cross section if the tapering part of it is conical by gradually grinding the tips down and counting the number of droplets coming per unit volume. In all measurements the volume of liquid used must be 10 ml.

The test proper is performed as follows: the cover of the dust chamber is removed. The burettes are placed into the holders and filled correspondingly with water and with wetting solution. The micro stopcocks are then opened to a point which would permit a flow of droplets at a constant rate; such for example as 10 ml in 3 minutes. Then the two glass containers are covered with the double lid, described just above. The cylindrical dust chamber is tightly closed, a weighed quantity of dust placed into the diffusor tube which is then connected through a calcium chloride tube to a source of compressed air and the actual comparative tests are begun.

Diffusion of the dust in the dust chamber takes one minute, after which the

compressed air is shut off. With the aid of the electromagnet the double lid is removed from the two receptacles; simultaneously the regular burette stopcocks are opened; the micro stopcocks have been set previously to a regulated position. After exactly 10 ml of liquid will have run out from the burettes, the stopcocks are closed and receptacles 1, 2 and 3, containing the dust suspension, and receptacle 4, containing dry dust, are removed from the dust chamber. The test is repeated 15 - 20 times and the final result calculated as the mean of the total of determinations. The test precision is $\pm 10\%$.

The quantity of dust collected by the liquid droplets is determined by nephelometer NFM. The pure water suspension of dust particles may partially agglomerate, thereby, affecting the true turbidity value; to prevent this, some wetting solution, used in the study, is added to the concentrated water suspension, used in the test. The same wetting solution is used in making a suspension of the dust freely precipitated in receptacle 4. The turbidity of this suspension is subtracted from each of the other three nephelometric readings. Turbidity (T) in the nephelometer used is the ratio between the reading (R) of the tested suspension and the reading (R_0) of the standard which is a cloudy glass prism of unit value. Hence, $T = R/R_0$. As an example the dust collecting ability of the 0.1% solution of a wetting agent DB is evaluated herein on the basis of experimental data.

After conclusion of the test, the content of each of the four receptacles were diluted to a final volume of 25 ml as follows: into the first receptacle containing 10 ml of dust suspension in water 10 ml of 0.1% DB solution and 5 ml of distilled water were added, making a volume of 25 ml; into the second and third receptacles, each containing a dust suspension in 10 ml of 0.1% DB solution, 15 ml of distilled water were added; into the fourth receptacle, with the free settled dust, 10 ml of 0.1% DB solution and 15 ml of distilled water were added. The turbidities were then determined as described, and mean values of each set of 15 - 20 tests were calculated.

The following symbols were used in formulating generalizations: E = total or general effectiveness of dust collecting; E_{ad} = adsorption effectiveness of dust collection; r_1 , r_2 and r_3 = cross-section radii of burette outlets used for water and for wetting agent determinations of E and E_{ad} ; R_1 , R_2 and R_3 = corresponding radii of droplets flowing out of the burettes; T_{Δ}^0 = relative value of dust-water suspension turbidity; T_c^0 = relative value of turbidity of

dust-wetting solution suspension turbidity ($r_1 = r_2$, $R_1 = R_2$); T_{c-ad}^0 = relative value of dust-wetting solution suspension turbidity ($r_1 = r_3$, $R_1 = R_2$); T_{Δ}^0 = relative value of freely settled dust suspension.

The turbidity of dispersion medium enters into all values of T . Relative values of turbidity will equal: for wetting agents $T_o = T_c^0 - T_{\Delta}^0$ and for water $T_w = T_w^0 - T_{\Delta}^0$.

Dust collecting ability of the wetting agents:

$$E = \frac{T_c}{T_w} \text{ and } E_{ad} = \frac{T_{c-ad}}{T_w}$$

Example: $T_w^0 = 0.39$; $T_c^0 = 0.47$; $T_{c-ad}^0 = 0.45$; $T_{\Delta}^0 = 0.34$.

From this the following corrected turbidity values are derived: $T_w = 0.05$; $T_c = 0.13$; $T_{c-ad} = 0.11$; $E = 0.13/0.05 = 2.60$; $E_{ad} = 0.11/0.05 = 2.20$.

Extensive experimental material accumulated indicated that the described device yielded precise and reproducible results in the investigation of the relation between dust collecting properties of wetting agents and their chemical composition, molecular constitution, solution concentration, etc. All this constitutes information of value to the proper selection of the most suitable wetting agents and most appropriate concentrations.

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Поступила 11/Х 1956 г.

The Use of Battery Combustion Chambers in the Purification of Industrial Emissions into Atmospheric Air.

By

S. P. Belousov, A. S. Dun, and I. I. Nikberg.

Gigiena i Sanitariya, Vol. 24, No. 4, 70-71, 1959.

The selection of effective measures for the purification of industrial emissions prior to their discharge into the atmospheric air plays an important part in the problem of sanitary protection of atmospheric air. Many different methods have been proposed and tried for the purification of waste gases from suspended substances, such as the dry methods by the use of cyclones, battery cyclones, etc.; wet gas purification by different types of scrubbers, filtration through porous materials and electrostatic precipitators. As a general rule these installations are used where only partial sanitary purification of the waste gases is required and the utilization of such gas purifying equipment to the full extent of their efficiency may not be imperative for the attainment of the prescribed sanitary conditions of the industrial plant. Certain secondary factors may be frequently responsible for the lowered efficiency of the above mentioned gas purifying installations. As an example of such factors mention can be made of the frequently arising difficulty of removing and utilizing of the gas purification products, which may result in the complete shutting off of their operation.

In this connection the use of gas purifying installations in an industrial plant is of considerable interest due to the fact that the nature of the plant's production made the continuous and efficient operation of the gas purifying installation an absolute prerequisite.

The gas purifying installation was of the type used in one of the Donbass (Don basin) coke-pitch plants of the coke-chemical industry. The coke was roasted in batteries of open flame furnaces of the "Yuzhkokremont" system; each battery consisted of 10 - 15 open flame furnaces.

Prior to this experimental study the plant had no gas purifying equipment; all the uncombusted products of pitch coking and the suspended particulate matter were discharged directly into the atmospheric air, heavily polluting it with dust, soot and gases. According to estimates the daily emission of suspended substances amounted to no less than 250 m (?). Fig. 1 is a schematic

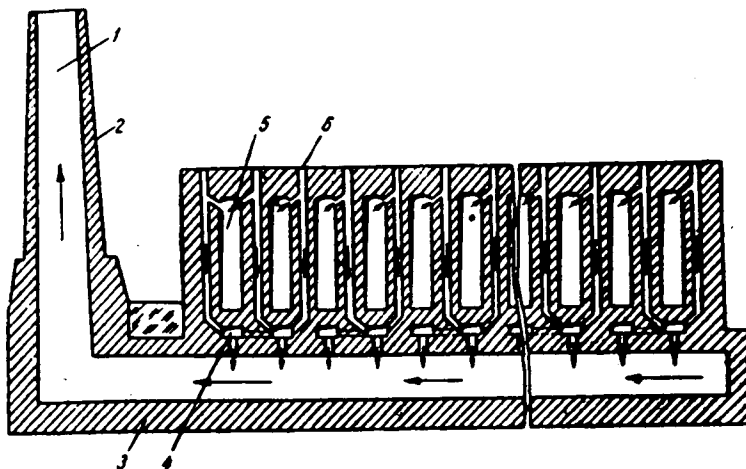


Fig. 1. Gas flow path in pitch-coke ovens before the installation of complete combustion chambers.

1 - Smokestack; 2 - firebrick lining; 3 - flue for gas collection; 4 - subfloor channel; 5 - furnace chamber; 6 - gas outflow channels.

type. Therefore, reconstruction of the battery furnaces was carried out which consisted in rebuilding part of the furnace into purification installations of

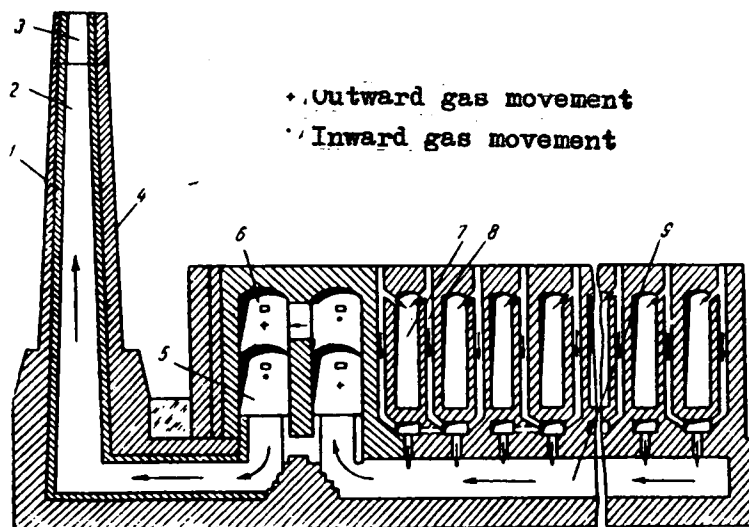


Fig. 2. Gas flow path in pitch-coke ovens after the installation of complete combustion chambers.

1 - Dinas brick lining; 2 - smokestack; 3 - 3 - 4 meters smoke stack extension; 4 - firebrick lining; 5 - gas combustion chamber; 6 - air hole; 7 - oven chamber; 8 - gas outflow channels; 9 - flue for gas collection.

illustration of the course of emission of waste gases before the introduction of the change.

In compliance with the demands of the State Sanitary Inspection Agency, the coking batteries were rebuilt to insure their more efficient combustion and a reduction in the atmospheric air pollution. Peculiarities of the technological process precluded the use of purification installations of the usual

type. Therefore, reconstruction of the battery furnaces was carried out which consisted in rebuilding part of the furnace into purification installations of the supplemental combustion chamber type. Thus, the exhaust gases coming from the furnace flues were passed through the supplemental combustion chambers before entering the smokestacks, as schematically illustrated in Fig. 2. The supplemental combustion of pitch-coke waste products is accomplished at 1150 - 1500°. This high temperature is attained by sucking in extra air through special openings in the supplemental combustion chamber.

The important feature of the structural and procedural changes introduced is the fact that the original basic plants in the pitch-coking plant remained undisturbed; another important feature of the modification was the fact that the normal operation of the supplemental combustion chamber assured the normal operation of the battery furnaces. Results of ten months experience with the supplemental combustion chamber proved its effectiveness with regard to the complete combustion of the pitch coking waste products, and demonstrated that pollution of the surrounding air was considerably reduced.

Rapid Determination of Nitrogen Oxides in the Air of Industrial Premises
by Special Tubular Indicators.

By

L. A. Mokhov, Yu. F. Udalov and V. S. Khalturin.

Zhurn. Prikl. Khim., Vol. 32, No. 2, 452-453, 1959.

The detection and quantitative determination of nitrogen oxides in plants which produce nitric and sulfuric acids, various types of nitrated organic compounds, azo dyes, etc., is of great importance from the sanitary, hygienic and technical viewpoints. Tests for the qualitative and quantitative presence of nitrogen oxides for the above mentioned purposes are made frequently; hence, there is need for a simple and rapid method which can be performed by persons of average education and of no special training.

Many of the existing methods for the determination of nitrogen oxides by the use of the Griss-Illosvay reagent were discussed in recent reports [1 - 3]. Determinations of nitrogen oxides by the method above referred to are made in the liquid phase; other methods use carriers which absorb oxides of nitrogen, and, in so doing, undergo change in color. Some authors [4] proposed the use of filter paper saturated with an alcoholic solution of benzidine as the absorbing material. Other authors proposed the use of silicagel onto which the Griss-Illosvay reagent has been adsorbed [5]. As the tested air passes over

the treated silicagel, the oxides of nitrogen are adsorbed and the color of the indicator changes. Quantitative estimations are made on the basis of the color intensity developed or on the depth of its penetration into the silicagel [6].

Fillipychev and Petrov [7] studied the action of nitrogen oxides on amino-compounds; their results indicated that the aromatic amines were easily diazotized in the presence in the air of dry nitrogen oxides. This observation led to the development of a method for the determination of nitrogen oxides and n-aminobenzoic acid [8]. The determination of nitrogen oxides [2] was based on the following: when air containing oxides of nitrogen is aspirated through a solution of amino-benzoic acid, the latter becomes diazotized. Subsequent combining of the diazotized n-aminobenzoic acid with H-acid produces a permanent dyestuff of a crimson-red color, the intensity of which is proportional to the concentration of nitrogen oxides present in the air.

This reaction has certain advantages over the generally used Griss-Illosvay method; however, like the latter, it is a liquid phase method which hinders its wide usage. Using this reaction and taking into consideration all the requisites [7] published in recent reports, these authors developed a new method for the rapid determination of nitrogen oxides by means of a tubular indicator [9]. The method is as follows: H-acid, n-aminobenzoic acid, and nickel chloride were adsorbed upon silicagel. The gel indicator thus obtained gradually changed its initial color from light pink to a brown-red in the presence of nitrogen oxides; the different shades of color depend upon the concentration of nitrogen oxides. As the result of the reaction between the oxides of nitrogen and the n-aminobenzoic acid diazonium salt is formed. The diazonium salt then combines with the H-acid which is the nitrogenous component in this reaction, while the nickel chloride acts as the catalytic agent to form the dyestuff.

The gel indicator is prepared in the following manner: 20 ml of a saturated alcoholic solution of H-acid was added to 1 g of silicagel and mixed for 2 minutes; the alcohol is evaporated while stirring; 20 ml of 0.5% alcoholic solution of n-aminobenzoic acid is then added; the indicator is dried with continuous stirring, and 0.5 ml of 0.1% of alcoholic solution of nickel chloride is added; the indicator is dried while stirring, until it becomes granular.

The tube indicators are prepared as follows: one end of a glass tube, 80 to 100 mm long and of 3 to 5 mm inside diameter, is drawn out and sealed. A glass wool or cotton wad is inserted through the open end as far as the cone-

shaped end, and the pad is gently packed; this is followed by a 3 mm layer of dried quartz sand or silicagel, and by a 2 mm layer of the silicagel indicator; the latter is overlayed by a 2 mm layer of dry quartz sand or silicagel; a pad of glass wool or of cotton is then placed over the sand, gently packed by means of a glass rod and sealed. The tube indicators can be stored indefinitely.

In making nitrogen oxide determination in the air, both ends of the tube are opened, and 100 ml of the air to be tested is aspirated through the tube from the wide end in the direction of the cone-shaped end; the coloring of the indicator is compared with that of a standard scale, and the amount of nitrogen oxides expressed in mg/li.

The standard scale is prepared by passing 100 ml of air through a series of tube indicators; the air contains progressively increased concentration of nitrogen oxides. The tubes are then sealed and stored. The respective shades of color can be recorded on paper by a color sensitive person.

The sensitivity of the proposed tubular indicators was determined by checking against the standard Griss-Ilosvai method; it was found to be 0.0005 mg/li.

Check determinations were made by the tube and Griss-Ilosvai methods. The results are listed in the Table below.

Results of oxides of nitrogen determinations by the indicator tube method of Griss-Ilosvai.

Calculated capacity concentration in mg/li	Colorimetric determination by the Griss-Ilosvai method in mg/li	Concentration determined by the indicator tube method in mg/li
0.00056	0.00055	0.0005
0.0028	0.0028	0.003
0.0034	0.0033	0.003
0.0053	0.0051	0.005
0.0055	0.0053	0.005
0.087	0.1	0.085
0.09	0.093	0.9
0.095	0.097	0.1
0.1	0.098	0.1
0.1	0.12	0.1

Note: Nitrogen oxides in the cubic content was obtained by means of a reaction of sodium nitrite and hydrochloric acid.

The data in the Table show that the tube indicator method for the determination of nitrogen oxides in the air was accurate and reliable. Its use is, therefore, recommended.

The specificity of the reaction was tested by aspirating through a tubular indicator vapors of ether, hydrochloric acid, mercury, carbon bisulfide, nitrogen, ammonia and carbon monoxide. No changes in the coloring of the tube indicators were noted.

Temperature changes from 10 to 25° recorded in industrial establishments, or changes in the relative humidity of the air within the range 40 - 90% had no effect on the determination results.

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Carbon Dioxide Absorption by Potash Solution Foam.

By

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Zhur. Priklad. Khimii, Vol. 29, No. 10, 1323-1329, 1956.

Plit and Shishkin [1] showed that poorly soluble gases were absorbed at a comparatively rapid rate in foam scrubbers. On the basis of that an experimental study was undertaken of the process of carbon dioxide absorption by a solution of potassium carbonate. Plit [2] established that the mechanism of such process followed the principles of chemical absorption associated with a reversible chemical reaction in the liquid phase, when the constant K_p of the rate of the chemical reaction exceeded respectively the values of the coefficient D_1 of carbon dioxide diffusion and the coefficient D_2 of the chemically active part of the absorbent in liquid film; this was in agreement with Posin's classification [3].

The rate of the process can be determined from equation

$$\frac{G}{F_t} = K_p \cdot c_t \quad (1)$$

where the coefficient of absorption K_p depends on the site of the reaction zone, and consequently, on the concentrations of the reacting substances. The impellent factor C_t of the process, which is the mean logarithmic value of the solution volume, is determined more easily from equation (1) than from the equations proposed by Pozin [3]. Therefore, equation (1) was used in processing the experimental data. The study of the course of the absorption process in foam scrubbers is complicated by the fact that the contact surface of the phases is unknown. On the other hand, the application of a study method in which the process rate, or the absorption coefficients, are functions of the absorption volume of the apparatus may present an erroneous picture of the course of the process, due to the fact that with the use of a foam head the coefficient of absorption and the type of the foam head, that is, the specific surfaces, are functions of common parameters. The present experiments were carried out with the aid of an apparatus which enabled the study of absorption on the basis of individual bubbles and which made possible the computation of the contact sur-

face of the phases. Such a procedure may not be in exact correspondence with the characteristics of a scrubber in practice, but the qualitative characteristics remain preserved, so that it becomes possible to study the effects of different factors and to evaluate them on a comparative basis.

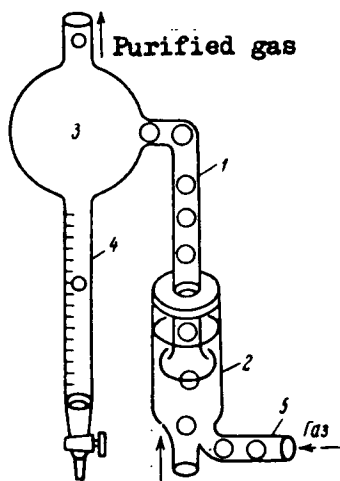


Fig. 1: Experimental apparatus
(See text for description)

The apparatus consists of an absorption tube 1, and the absorbent solution container 2. The upper end of the absorption tube is connected with spherical vessel 3, having a fused-in burette 4; the lower end of the absorption tube is enlarged in a conical formation and is submerged below the surface of the absorbent solution. A carbon dioxide-air mixture enters through nozzle 5; simultaneously foam bubbles were created in a weak saponin solution. Through the cone-shaped end of tube 1 the bubbles ascended into the absorption tube and moved along as short equally sized cylinders. The number of bubbles during the experiment was computed according to the following formula:

$$\frac{h_{cp}}{w} \cdot n = \tau \quad (2)$$

where h_{cp} denotes the average height of the small bubble cylinders measured in the course of the experiment;

w denotes the rate of the cylinder movement;

τ denotes the duration of the experiment;

n denotes the total number of cylinders.

The phase contact surface was computed according to the following formula:

$$F = \left(2 \frac{d^2}{4} + \pi d h_{cp} \right) \times n \quad (3)$$

Upon leaving the absorption tube and entering the spherical container the volume of the bubbles changes. This destroys the bubble, and the liquid accumulates in burette 4 where it can be measured accurately.

The first set of experiments was devoted to the study of the effect of the surface-active admixture concentration upon the course of the absorption process. The experiments were conducted with mixtures containing respectively 7.16%

and 21.8% of carbon dioxide by volume and 150 g/li of K_2CO_3 . The saponin concentration ranged from 0 to 4 g/li. The data of the experiments are plotted in Figs. 2 and 3. Curves in Fig. 2 show the functional relation between ab-

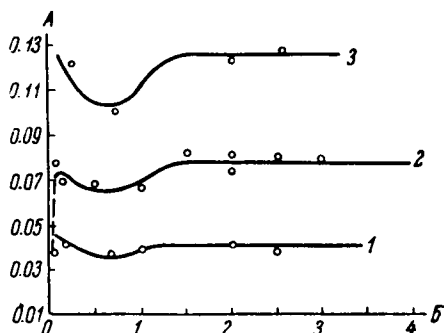


Fig. 2.

Effect of saponine concentration on absorption rate

Ordinate - Absorption rate in $kg/m^2/hr$

Abscissa - Saponine concentration in g/li of solution

Carbon dioxide % and C^o correspondingly:

1 - 7 and 14, 2 - 16 and 18, 3 - 21.8 and 14

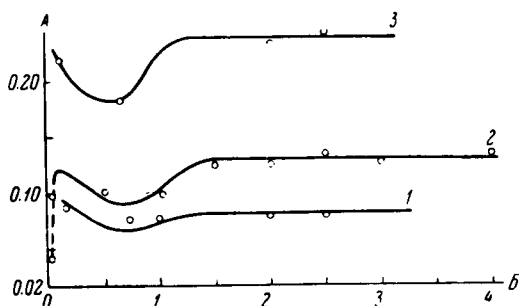


Fig. 3. Effect of saponine concentration on the absorption coefficient

Ordinate - Absorption coefficient in $kg/m^2/hr/mol/li$

Abscissa - Saponine concentration in g/li of solution

Gas % and C^o correspondingly:

1 - 7 and 14, 2 - 16 and 18;
3 - 21.8 and 14

sorption rate and the saponin concentration, expressed as: $\frac{G}{F}$.

Curves in Fig. 3 show the functional relation between the ab-

sorption coefficient and saponin concentration. It is apparent that

both sets of curves are of a similar type, indicating that a decrease

in the absorption rate and in the absorption coefficient occurred at

low saponin concentrations such as

0.6 g/li; at concentrations ranging

within the limits 0.6 to 1 g/li the

absorption rate and the absorption

coefficient rose to certain maximal values.

Further increase in the saponin concen-

tration showed no appreciable effects upon

the rate or coefficient of absorption.

The similarity of the curves points to

the existence of a definite relationship

between the diffusion resistance and the

respective saponin concentration in the

solution. Concentration of saponin with-

in the limits of 1 to 1.1 g/li resulted

in the formation of a saturated adsorp-

tion layer which characteristically man-

ifested a minimal diffusion resistance.

The maximal resistance appears in the range of unsaturated layers with a concentration close to 0.6 g/li. The latter is in accord with the results of other investigators, in particular of Pokhil [4], who showed that maximum viscosity elicited by the islet structure of an unsaturated layer occurred in the region of the saturated film. As concentration increased the film density also

increased accompanied by a rapid destruction of the islets which resulted in a sharp drop in the film viscosity at the point nearing saturation.

It is known that the ratio between diffusion resistance and viscosity is of the order of $1/6$ and that the absorption coefficient was inversely proportional to the viscosity in a $5/6$ ratio. For this reason the curves obtained closely followed the law of the viscosity changes in an unsaturated adsorption layer. After the adsorption layer became saturated, no further changes were caused in the absorption coefficient by increase in saponin concentration; the coefficient acquired a constant value, approximately corresponding to the absorption by a solution with 0.1 g/li saponin concentration. Of the above discussed two possible concentrations with maximum absorption coefficients the 1 to 1.1 g/li concentration should be regarded as the optimal, because of the greater firmness of its adsorption films which form the foam bubbles, and consequently the scrubber foam head. According to the theory advanced by Tolmud the firmness of the adsorption layers reached its maximum before a saturated adsorption layer was formed; in the case of saponin solutions this holds true only for freshly prepared solutions. Tolmud, Sukhoval'skaya and Lubman [5] showed that the firmness of a saponin film increased with "aging", and that the firmness of an "aged" film increased with the concentration. Accordingly the rate of gas flow through the scrubber process in each particular case constitutes the factor determining the saponin concentration most appropriately, even though occasionally it may be greater than 1.1 g/li. However, the usual absorption coefficient which corresponds to the optimal concentration for diffusion resistances, i.e., $1 - 1.1$ g/li, may be used in the computations.

Another factor of equal importance is the effect of the adsorption layer at the contact surface of the phases on the rate of the absorption process. Data available on the subject, particularly with reference to the usual film absorption, are highly contradictory. According to some data a decrease in surface tension resulted in a greater absorption coefficient; in connection with this, it is recommended that special surface-active admixtures be introduced into the solution [6]. However, Ternavskii and Belopol'skii stated [7] that, contrary to the above, the mass-transfer coefficient was greatly reduced by the addition of even small doses of surface active agents. For this reason, and in order to compare absorption rates, experiments were conducted with K_2CO_3 solutions containing no saponin and 16% gas-air mixtures. The dotted extensions to the zero

point of curves in Figs. 2 and 3 present the results of such experiments. It can be seen that the presence of an adsorption layer at the phase contact led to a considerable increase in the absorption coefficient and, consequently, to an acceleration of the absorption process, the rate of which was doubled. The adsorption layer lowered the surface tension of the solution at the surface of phase separation; however, it also enhanced the diffusion of the gas into the liquid thereby enhancing the absorption rate.

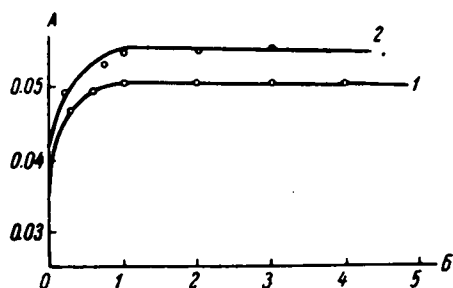


Fig. 4. Effect of saponine concentration of the amount of solution per foam bubble.

Ordinate - u/w ratio; abscissa - saponine g/li. Gas %: 1 - 18, 2 - 14.

Fig. 4 shows the ratios between the volume of the gas (w) that passed through, and the volume of the solution (u) collected in the burette during the experiment and at different saponin concentrations. The w/u ratios reflected the capability of the adsorption films,

which formed the bubbles, to entrap a definite amount of solution. The greater the value of w/u , the lower was the amount of solution retained by a bubble, and

vice versa. An increase in the concentration of saponin reduced the value of w/u , and consequently increased the quantity of the entrapped solution. The increase persisted up to the formation of a saturated adsorption layer. Thereafter, the ratio w/u remained constant. Under the conditions of the experiment the value of the ratio at 18.5° was 19.6 and at 14° it was 18.3. The thickness of the film forming bubbles, computed on the basis of above data, ranged between 0.1 - 0.15 mm.

Fig. 5 shows the results of experiments conducted in the study of the effect of absorbent solution concentration upon the absorption coefficient. The experiments were conducted with 7% and 16% gas at 14°, an optimal saponin concentration of 1.0 g/li. The concentration of the absorbent solution varied between 50 to 200 g/li of K_2CO_3 .

Increase in the absorption solution concentration reduced the absorption coefficient. Nevertheless, it does not follow that the solution concentration should be made as low as possible. A higher solution concentration has a greater chemical capacity; hence, where the larger capacity, consequent to a greater concentration, rose faster than the corresponding reduction of the absorption co-

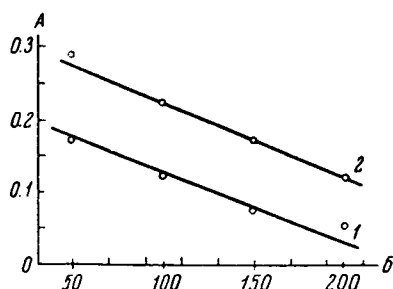


Fig. 5. Effect of saponine concentration on the absorption coefficient
 Ordinate - Absorption coefficient in $\text{kg/m}^2/\text{hr/mol/li}$
 Abscissa - K_2CO_3 in g/li
 Gas percent: 1 - 7.2, 2 - 16

efficient, the use of concentrated solutions may be more profitable. The maximum rate of the process for the system under consideration was obtained at 150 g/li. Up to this maximum the rate of the process increased with the concentration. At higher concentrations the absorption coefficient decreased faster than the rise in the chemical capacity of the solution, consequently, the rate of the process decreased. It can be concluded that

the optimal concentration for the absorption of carbon dioxide by a foam head corresponded approximately to the molar concentration or, more precisely, to 1.09.

The rate of the absorption coefficient change may be expressed by the following empirical formula:

$$K_F = K_0 \frac{150}{a} \quad (4)$$

where a denotes the concentration of solution in g/li;

K_0 denotes the absorption coefficient at solution concentration of 150 g/li.

The reaction zone position is determined by the concentration of the absorbing solution and by the concentration of the gas to be absorbed; this points to the existence of an absorption coefficient which depended upon the concentration of the gas to be absorbed. Such an assumption was substantiated by experiments with gas concentrations ranging from 5% to 38% by volume, at 18.5° . The concentration of the absorbing solution was 150 g/li of K_2CO_3 and 1 g/li of saponin.

Fig. 6 shows that an increase in gas concentration increased the absorption coefficient according to the following empirical rule:

$$K^1 = p^{1.23} \quad (5)$$

where K^1 stands for the value of the absorption coefficient at 18.5° expressed in $\text{kg/m}^2 \times \text{hour.mol/li}$;

p denotes the gas concentration expressed in fractions of unity.

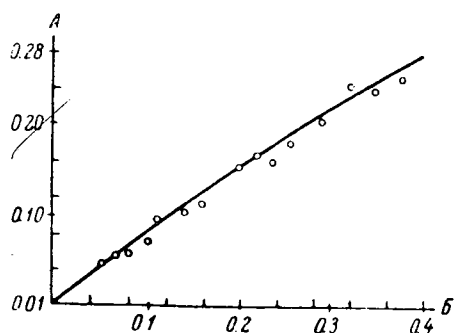


Fig. 6. Effect of gas concentration on the absorption coefficient
 Ordinate - Absorption coefficient in $\text{kg/m}^2/\text{hr/mol/li}$
 Abscissa - Gas concentration in fraction of a unit

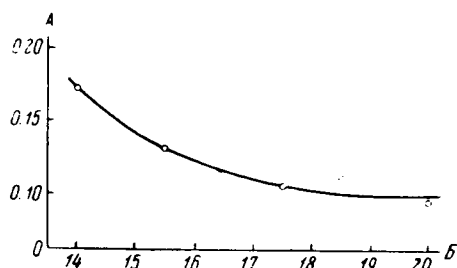


Fig. 7. Effect of temperature at 16% of gas on the absorption coefficient.
 Ordinate - Absorption coefficient in $\text{kg/m}^2/\text{hr/mol/li}$
 Abscissa - Temperature in $^{\circ}\text{C}$.

Unlike the concentration of the absorbing solution, the rate of the absorption steadily increased with the increase in gas concentration. This was due to the fact that with the increase in the absorption coefficient the chemical capacity of the solution also increased.

Because of the specific nature of the experiments, studies of temperature effect upon the rate of absorption were limited to the range of 14° to 20° . The effect of temperature upon the absorption coefficient is shown in Fig. 7.

The curve shows that the absorption coefficient diminished with the rise in temperature. Absorption coefficient values within the limits of 14° to 18° can be determined by the following formula:

$$K_t = K^1 \frac{257}{t^{1.9}} \quad (6)$$

where t denotes temperature in degrees Centigrade;

K^1 denotes the value of the absorption coefficient at 18.5° .

While the mean logarithmic value of the solution capacity increased slightly with a rise in temperature, the rate of the absorption process diminished. Thus, absorption by the foam bubble was more intense at lower temperatures.

The effects of basic factors on absorption rate of gases by discrete bubbles was investigated. The optimal concentration of K_2CO_3 and saponin solutions, the absorption coefficient at a given gas concentration can be computed with the aid of formula (5), and later correcting for temperature according to formula (6). If for any reason the absorbing solution concentration exceeds or falls below 150 g/li of K_2CO_3 , then a correction for concentration can be introduced with the aid of formula (4). The absorption coefficient determined in this way holds

true only within the conditions of the conducted experiments. In this case the conditions were: absorption by discrete bubbles which moved at an average rate of 3.8 cm/sec, a rate which was maintained throughout all the experiments.

In group of intimately close multibubble, or foam formation, the absorption coefficient largely depends on the rate of the foam movement. At higher rates of foam movement the phenomenon of solution entrapping increases at the moment of bubble foam formation, due to the fact that the quantity of liquid retained in the film increased markedly. An analogous phenomenon was observed with the movement of a discrete bubble; as soon as its diameter became greater than the diameter of the absorption tube, its movement became impeded, accompanied by greater solution entrapping.

From the viewpoint of the course of adsorption the fact just mentioned is of considerable importance. This was proven by the experiments conducted at different rates of gas movement. As the rate of gas movement increased, the ratio w/u , i.e., the ratio of gas phase to the liquid phase diminished and, therefore, the amount of the solution retained by each bubble increased. This brought about a sharply increased turbulence in the movement of the film liquid particles which formed the bubbles, thereby lowering the diffusion resistance. The absorption coefficient and the rate of absorption increased.

In the case of foam scrubbers, this factor can not be accounted for with the aid of any coefficient, due to the fact that the "crowding" conditions in the course of bubble group movement through the absorption tube differ greatly. The needed correction must be determined experimentally with the foam scrubber in operation.

Conclusions.

A study of the effects of different factors on the course of carbon dioxide absorption by discrete K_2CO_3 solution bubbles indicated that absorption by foam bubbles proceeded in accordance with special hydrodynamic conditions which lowered diffusion resistance and enhanced the kinetics of the process.

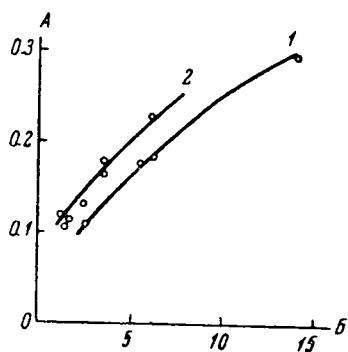


Fig. 8. Effect of velocity of bubble movement on absorption coefficient.

Ordinate - Absorption coefficient in $kg/m^2/hr/mil/li$

Abscissa - Velocity of bubble movement in cm/sec.

Gas γ : 1 - 19.5, 2 - 27.2

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Purification of Exhaust Gases of a Sulfuric Acid Tower Plant by a Flowmeter Pipe Type of Apparatus.

By

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Zhurnal Prikladnoy Khimii, Vol. 31, No. 2, 178-186, 1958.

The purpose of this investigation was to test the flowmeter pipe, or Venturi pipe type, of apparatus for the recovery of spray, sulfuric acid fog (aerosol) and nitrogen oxides from the exhaust gases of a sulfuric acid tower plant. The experimental apparatus was treated in one of the tower system plants of the H_2SO_4 industry. It was hoped that in addition to the sanitary purification such an arrangement might reduce the consumption of nitric acid and cut down the sulfuric acid waste.

The acidity of the exhaust gases in plants operated by the tower system depends principally on the presence of nitrogen oxides ($\sim 0.2 \div 0.35\%$ NO , NO_2 or $6 \div 10 \frac{gHNO_3}{m^3 \text{ of gas}}$) accompanied by a low rate of NO oxidation, which complicates

the process of purification to a considerable degree. Furthermore, the gases contained spray and fog of sulfuric acid ($1.5 \div 3 \frac{gH_2SO_4}{m^3 \text{ of gas}}$) and sulfur dioxide

[1, 2]. The acidity of the exhaust gases also depends on the rate of the system's operation, type of construction, technological process parameters, the condition of the equipment, methods of acid distribution, etc. The formation

of H_2SO_4 spray and of fog may take place in the wet electrostatic precipitators installed at the end of the system; however, such filters do not collect such gaseous components as nitrogen oxides and SO_2 . These electrostatic precipitators do not attain a sufficiently high degree of gas purification at all times [3].

The use of concentrated H_2SO_4 spray in the last absorption tower of the nitrore system reduced the H_2SO_4 in the exhaust gases by approximately 50% [4], and the loss of nitrogen oxides by 30 to 35% [5]. The use of commercially delivered acid proved costly and, therefore, inexpedient. High exhaust stacks improved the sanitary conditions only in the immediate production surroundings, but failed to be of help in the purification of the exhaust gases or in the recovery of economically valuable components.

Apparatus of the type of flowmeter pipes have been used successfully by many plants for exhaust gas purification [6 - 8]. However, such apparatus has not been used in plants producing H_2SO_4 by nitrore installations of the tower type.

The experimental set-up used in the present experiments consisted of two units: a small assembly, producing up to $50 \text{ m}^3/\text{hour}$, and a larger one producing up to $500 \text{ m}^3/\text{hour}$.

In tube No. 1, shown in Fig. 1, the fluid entered the main channel of the apparatus at an angle; in tube No. 2, the fluid entered tangentially and became distributed evenly over the perimeter of the diffuser. In this type of tube the gap between the collector (konfuzor) and diffuser is controlled by rotating the head of the apparatus.

Apparatus No. 3, shown in Fig. 3, had a radial fluid feed in relation to its main axis. The separator walls of the small unit were arranged concentrically, which forced the passing gas to impinge upon the surface of the liquid twice in succession.

The type of tube shown in Fig. 4 was tested in connection with the large unit. This tube had two radial fluid feeds set at 90° , and a separator of the type of abbreviated cyclone TsKTI. No control fluid feed was used in the experiments described.

Water was used as the absorbing fluid. It could also be fed into the reaction zone of the tower system in place of technological water which contained absorbed nitrogen oxide and sulfuric acid. The exhaust gases were purified in packed scrubbers in a similar manner [9, 10].

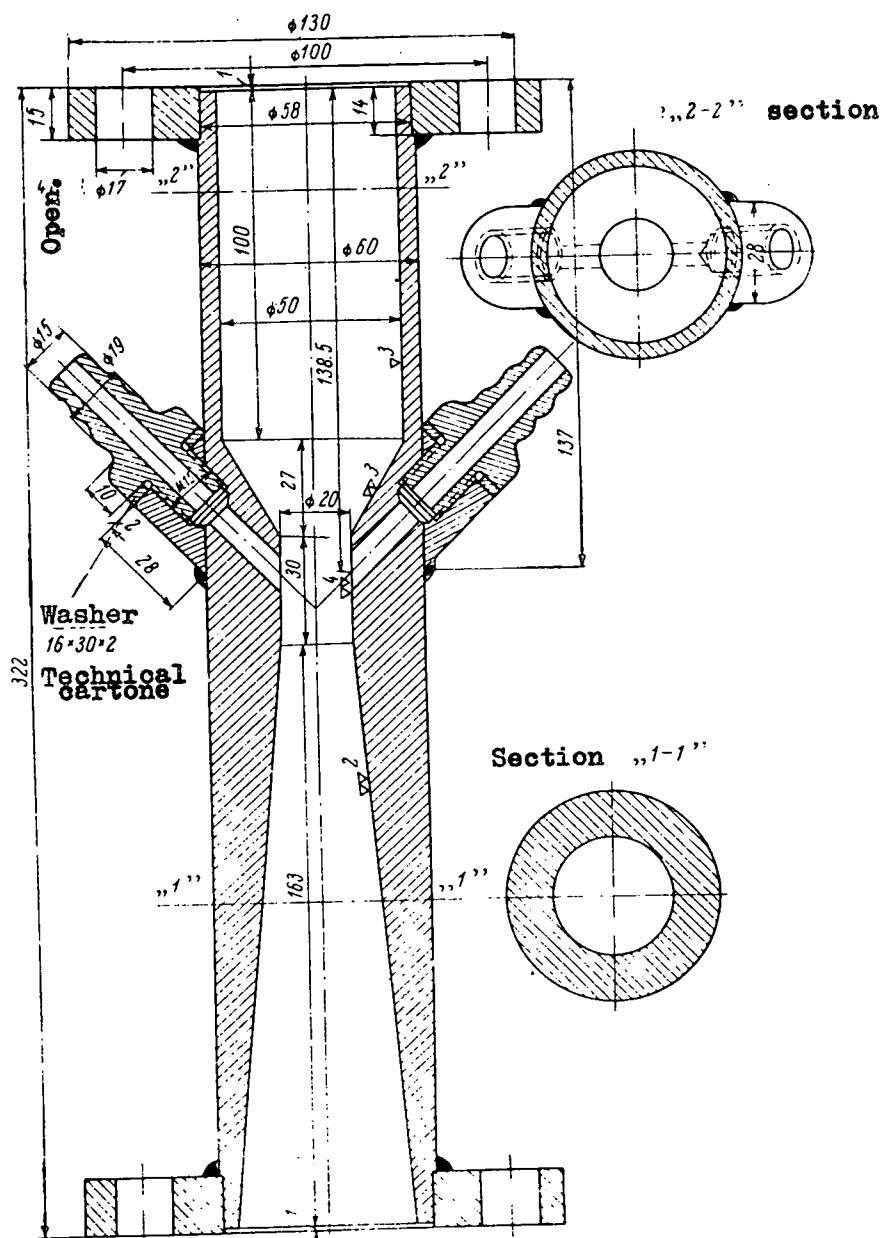


Fig. 1. Apparatus No. 1 with water inflow at an angle to the axis of the tube.
(Dimensions in Figs. 1, 2, 3 and 4 are in mm)

A soda solution in a concentration of $5 \div 30$ g/li was also used as the absorbing fluid. Because of the complexity of analyzing gaseous and liquid phases, different assembly types were tested at the experimental installation shown in Fig. 5. Gas for the tests was taken from the conduit which connected the last

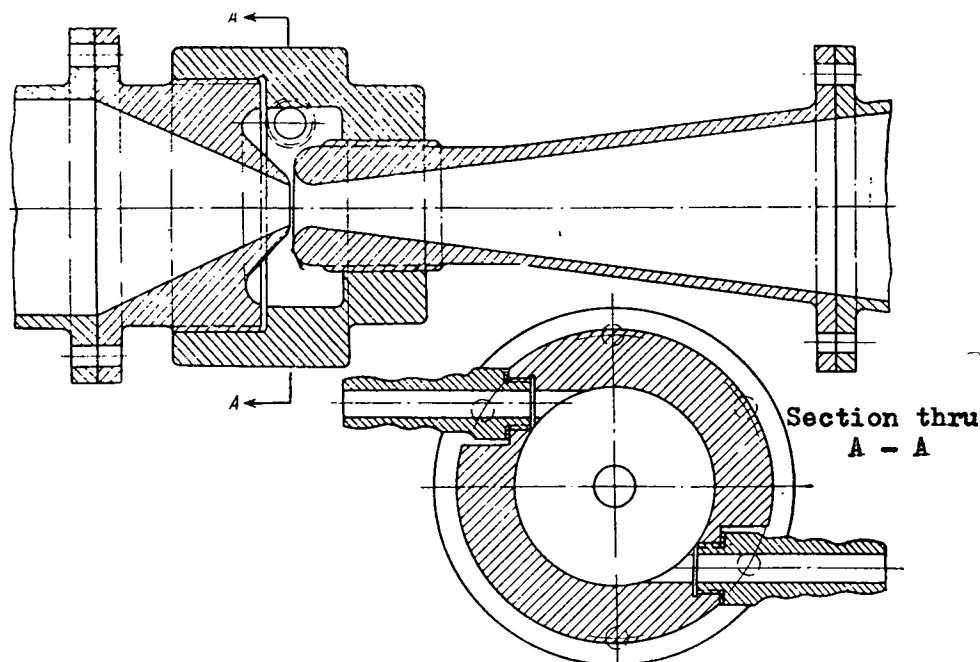


Fig. 2. Apparatus No. 2 with water inflow tangential to mixing chamber.

tower of the system with the exhaust gas cyclone, and was drawn through the installation by the force of partial air vacuum caused by the exhaust fan.

[The following persons participated in the analytical work: N. M. Kazakova, M. Yu. Viner, M. S. Gutman, V. Kosovets and R. Varvarskaya.]

The gas which passed through apparatus No. 4 was measured by a Venturi tube; the gas which passed through the small unit was determined diaphragmatically. Fluid consumption was measured by flowmeters. Control measurements were made by diverting the fluid flow into graduated containers. Content of H_2SO_4 spray and of nitrogen oxides was determined with the aid of glass wool or hygroscopic cotton and vacuum containers of 20 liters capacity. Glass filters No. 4 and colorimetric tubes were also used. Results of analyses were calculated in the usual way [11]. Under the experimental conditions SO_2 concentration in the exhaust gases was negligible, amounting approximately to 0.1%. The concentration of nitrogen oxides was also relatively low, so that the SO_2 oxidation during the gas aspiration could be disregarded. The ratio of gas volume to the fluid volume was taken as one of the basic parameters. This ratio is designated as $g:f$ and is an immeasurable quantity; the gas volume was reduced

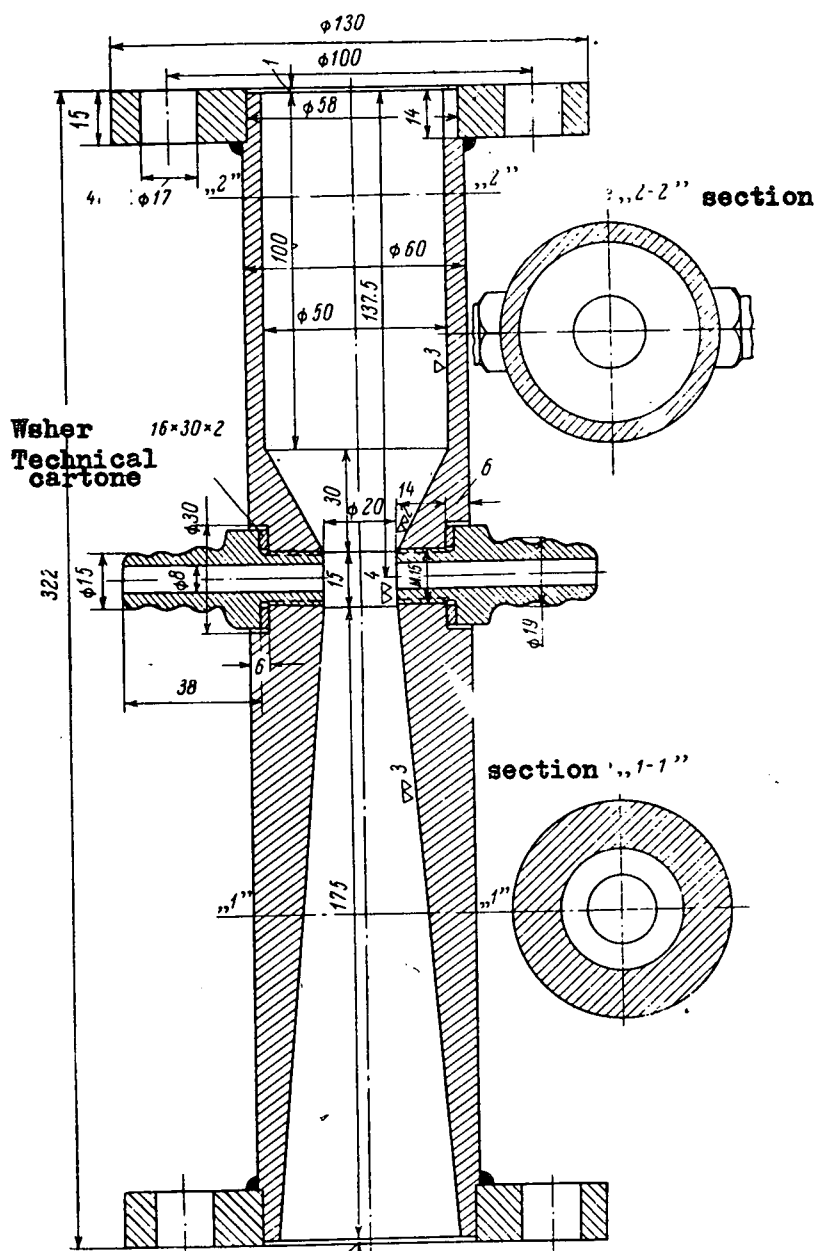


Fig. 3. Apparatus No. 3 with water inflow radial to the axis of the tube.

to standard temperature and pressure. The latter determines the gravity force of the gas flow and the hydrodynamic conditions of the apparatus. The specific fluid consumption expressed in li/nm^3 , is determined as the reciprocal of the ratio g/f .

An investigation of the hydrodynamics of the gas and fluid flow in the tubes described showed that a fluid inflow at an angle to the main axle of the tube considerably lowered the pressure drop of the apparatus (Δp) as compared with the radial inflow as shown by curves in Fig. 6. Δp increased in the case of tube No. 2 with the widening of the opening between the collector (konfuzor) and the diffuser. For apparatus No. 4, Δp depended on

the consumption of gas as shown in curves of Fig. 7. For values of $g/f \geq 1000$, Δp was practically independent of this ratio, and was equivalent $40 \div 120$ mm of water column; it depended upon the construction of the apparatus, the rate of gas flow in the orifice of the tube, the fluid consumption, and the angle of inflow.

The mechanism of absorption of the acid components from the exhaust gases

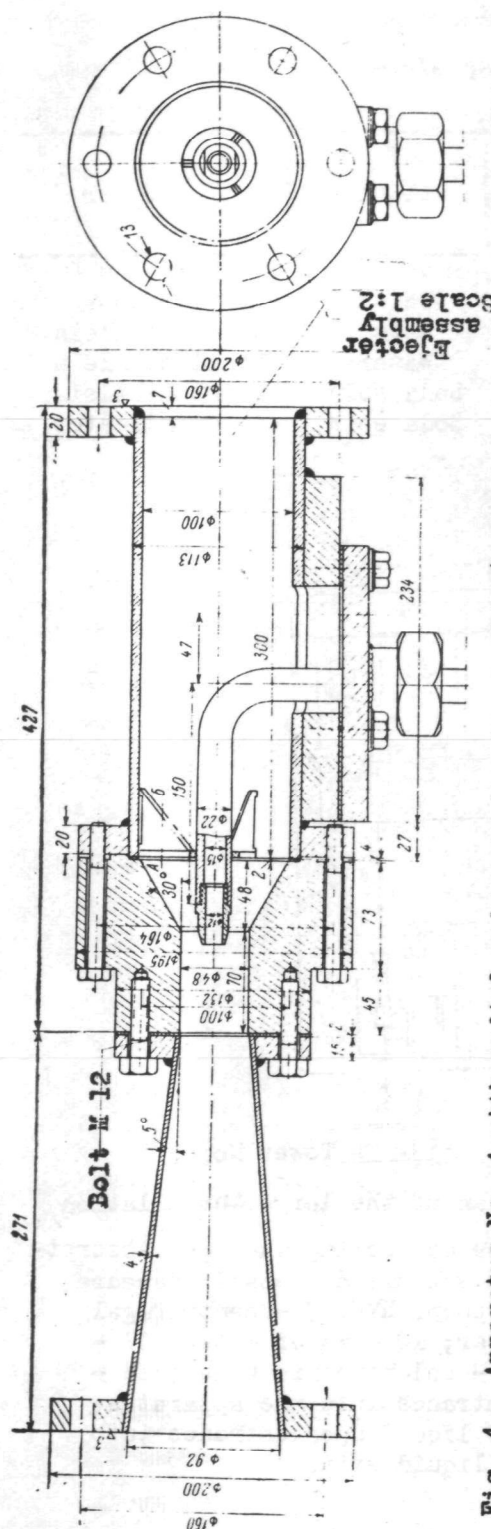


Fig. 4. Apparatus No. 4 with radial and central water inflow (Radial inflow is not shown in graph)

was studied by titrating the fluid upon entering and leaving the apparatus and by provisionally determining the acidity in $\frac{gH_2SO_4}{nm^3 \text{ of gas}}$, (designated as parameter A) and in $\frac{gH_2SO_4}{li \text{ of solution}}$, (designated as parameter B). The following formula determines the ratio between A and B:

$$\frac{B}{A} = \frac{g}{f} \times 1000$$

It has been experimentally established that the value of A diminished with the increase in g:f, and that it was practically independent of the gas flow; that parameter B gradually increased with the increase of g:f, and that it depended only slightly on the gas flow. The following Table shows values of A for different tubes.

An examination of the data indicated that, as a rule, the highest values of A prevailed in the case of tubes No. 4 and No. 2, and, inversely, the lowest values of A were found in the case of tube No. 1. In the Table following are presented comparative degrees of absorption of acid components from the tower system exhaust gases using the different tubes described.

The data presented show that with a ratio g:f greater than 500 and water as the absorbing fluid, the highest values of η appeared in the case of tube No. 2. Apparatus No. 1 performed more efficiently than apparatus No. 3 with high g:f values and vice versa.

Parameter A as a function of g/f ratio.

Pipe No.	Pipe diameter in mm	Parameter A at g/f ratio equal to				Liquid	Indicator
		250	500	700	1000		
1	20	1.05	0.9	0.73	0.52	Water	Methyl orange
2	11	3.3	3.05	2.7	2.5	Water	Phenolphthalein
3	20	2.8	2.5	2.1	1.80	Water	Phenolphthalein
4	48	5.5	4.6	3.85	3.1	Soda soln.	Phenolphthalein
4	48	3.3	3.15	3.0	2.8	Soda soln.	Mixed indicator

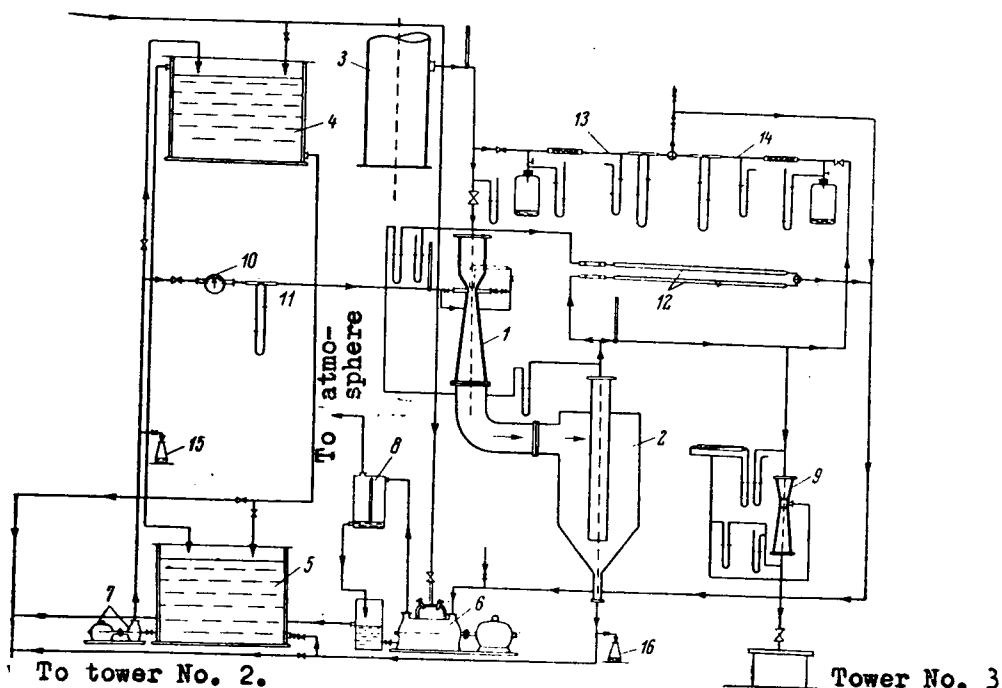


Fig. No. 5. Operational and technological plan of the large installation

1 - Apparatus No. 4; 2 - separator; 3 - device connecting the last absorption tower with the cyclone of the exhaust gas system; 4 - small pressure tank; 5 - small circulation tank; 6 - vacuum pump, RMK; 7 - centrifugal pump; 8 - spray catcher, RMK; 9 - Venturi meter; 10 - water meter; 11 - flow meter for liquid entering apparatus; 12 - colorimetric tubes; 13 - line (level) of taking samples of gas upon entrance into the apparatus; 14 - ditto at gas exit; 15 - sample taking of liquid upon entrance into the apparatus; 16 - ditto at liquid exit.

Values of η for different pipes.

Pipe No.	Pipe diameter in mm	Gas used nm ³ /hour	Gas velocity at throat in m/sec	Absorber	Value of η at g/f ratio equal			
					250	500	700	1000
1	20	33 - 60	29.4 - 52.9	Water	35.0	31.5	27.5	24.0
2	11	23 - 58	67.3 - 170.0	Water	26.5	27.2	28.0	29.0
3	20	27 - 59	23.7 - 52.0	Water	-	34.0	28.0	22.0
4	48	220 - 490	33.8 - 74.5	Soda soln.	38.5	39.0	39.5	10.0

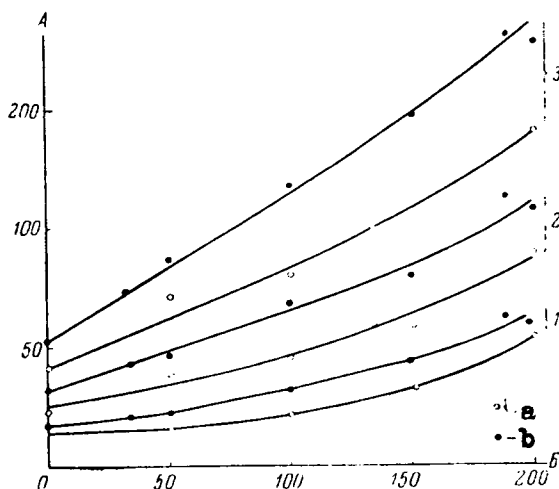


Fig. 6. Comparison of hydrolic resistance (pressure drop) of apparatus No. 1 and No. 3 having the same throat diameters at different rates of gas flow,

Ordinate - Hydrolic resistance (pressure drop) p in mm of water column; abscissa - water consumption in li/hr.

Gas flow in m³/hr: 1 - 20; 2 - 30; 3 - 40.
a - Apparatus No. 1; b - apparatus No. 3.

and H₂SO₄ content at the entrance ~ 1.4 g/nm³, η was equal approximately to 80% and that it was practically independent of the g:f ratio. In packed towers the absorption was considerably lower [9, 10], despite the greater spray and fog concentration and the considerably longer stay in the apparatus. The rate of spray and fog absorption in the tubes can be still higher, as is shown in previously published reports [12, 13]. A comparison of the degree of absorption of low concentrations of oxides of nitrogen (η) from nitrose gases in apparatus

The curve in Fig. 6 indicates that the value of η was practically independent of the ratio g:f, and that a value for η approximately equal to 40% was attained in apparatus No. 4 with a soda solution. The average content of acid components of the gas entering the tubes amounted approximately to $8 \div 10$ g/nm³ and consisted principally of oxides of nitrogen. The rate of spray and of sulfuric acid fog absorption in the tube was determined individually. Numerous experiments indicated that for tube No. 4, with a consumption of gas ~ 400 nm³/hour, an average spray

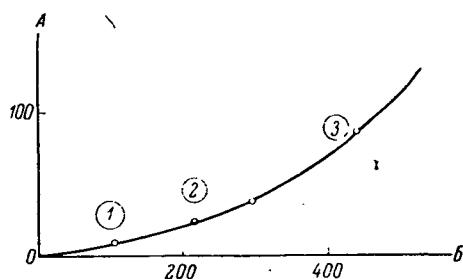


Fig. 7. Hydrolic resistance (pressure drop) of tube No. 4 as the function of volume flow rate of gas at liquid consumption of 145 - 160 li/hr.

Ordinate - Hydrolic resistance (pressure drop) p ; abscissa - gas flow rate in m^3/hr .

Ratio of gas to liquid (g/f):

1 - 660; 2 - 1330; 3 - 2700.

of different construction indicated that the values of η attained in the experiments under discussion were of the same order as those obtained by other investigators [5, 10, 14 - 17]. However, the rate of absorption in the flowmeter tubes was considerably higher, while the overall dimensions of the apparatus were smaller.

The comparatively low values obtained for η can be explained

principally by the fact that the nitrogen oxides were not properly conditioned for most favorable absorption. Technological conditions which prevail in a tower system with a slight peroxidation of NO toward the end of the system, enhance the absorption of oxides of nitrogen from exhaust gases by alkaline solutions.

A study was made of the operational characteristics of the flowmeter tube type of apparatus along with a comparison of their efficiency with that of packed towers. This was done as follows: the coefficients of volume rate absorption were computed according to formula $Nu^1 = \phi(Re, Pr)$ for apparatus working on the principle of spray dispersion of the reaction fluid [18], and also by the formula of Nukiyama and Tanasava [19] used in computing average drop diameters.

The volume rate coefficient of absorption of N_2O_3 in relation to the tube orifice was $\sim 400,000 \frac{kg N_2O_3}{m^3 \text{ hour atm}}$. For the apparatus as a whole the value of this coefficient was considerably lower. The experimental values of this coefficient were $50,000 \frac{kg N_2O_3}{m^3 \text{ hour atm}}$, which is approximately 80 to 100 times greater than for packed towers.

The total consumption of electric energy per 1 t H_2SO_4 was 5 to 6 kilowatt-hours, or 10 to 12% of the total electric power used in the production of 1 t of sulfuric acid by the tower system.

The g:f ratio in these computations was taken as equal to $1000 \div 1200$ and

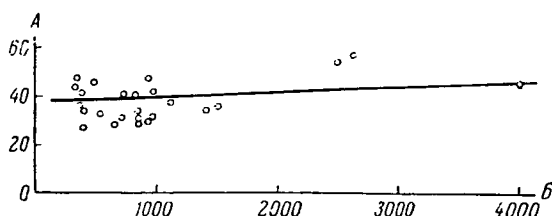


Fig. 8. Effect of ratio g/f in apparatus No. 4 on the degree of exhaust gas purification η .

Ordinate - degree of absorption η in %.

Abscissa - ratio g/f .

$\Delta p = 250$ mm of water column, plus an allowance for resistance of the communication and separator systems.

Conclusions.

1. In cases of linear rate of gas flow at the tube orifice ranging between $30 \div 75$ m/sec, g/f of 750 to 250, and water as the absorber, the pressure drop (Δp) ranged between 40 and 120 mm of water. The value of Δp is less for a tube with an angle fluid flow.
2. Using flowmeter tubes in alkaline absorption of H_2SO_4 spray or fog and of nitrogen oxides of average initial concentration equal approximately to $10 \frac{g H_2SO_4}{nm^3 gas}$, the absorption rate was $\sim 40\%$ as determined by provisional calculation of H_2SO_4 acidity.
3. The comparatively low degree of total exhaust gas purification may be explained by the lack of preparation (conditioning) of nitrogen oxides to absorption. The acidity of the exhaust gases depended basically on the oxides of nitrogen.
4. The power consumed in the operation of the flowmeter tube type of apparatus in the purification of exhaust gases emitted by the tower nitrose system ranged between 5 - 6 kilowatt-hours per ton of H_2SO_4 , or 10 to 12% of the total power used in the production of one ton of sulfuric acid by the nitrose method.

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Scrubber Application to Carbon Dioxide Absorption by Potassium Carbonate Solution.

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Absorption of carbon dioxide by a solution of potash is widely used in practice [1]. Nevertheless, the process has not been thoroughly investigated; it needs to be studied in greater detail as a step toward the solution of other practical problems.

According to the present classification [2, 3] the mechanism of CO_2 absorption by K_2CO_3 solution is one of chemisorption with a reversible chemical reaction in the liquid phase. The course followed by such a reaction is schematically presented in Fig. 1. The concentration of the absorbing gas within the limits of the gas diffusion layer d_g changes from P to P_g or gas equilibrium. Neutralization of the mono-molecular layer occurs at the interphase surface, that is at points of contact between the gas and the liquid. Immediately thereafter, the zone of reaction is shifted deeper into the liquid diffusion layer d_f until a dynamic equilibrium is reached, as graphically illustrated in Fig. 1. In this way it is possible to attain a reaction zone of equivalent amounts of the gas to be absorbed and of the chemically active absorber. In this case the

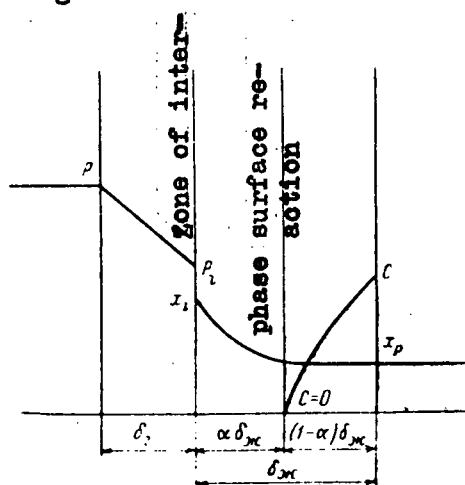


Fig. 1. Schematic presentation of absorption mechanism

reaction zone divides the diffusion layer into a neutralized part (αd_f) and a non-neutralized part $(1-\alpha)d_f$; at the same time the concentration of the dissolved gas in the neutralized part of the layer changes from x_1 at the interphase to equilibrium x_p in the reaction zone.

Pozin proposed a kinetic equation expressing the course of scrubber absorption for similar systems, which is based on values the practical determination of which presents certain difficulties. Therefore,

the experimental data were processed according to the following equation:

$$\frac{G}{F \times \tau} = K \times C_m \quad (1)$$

The impellent dynamic factor C_m in this equation is the mean logarithmic difference of the solution capacity expressed in mol/li. It should be noted that changes in the chemical capacity of the solution at the depth of the non-neutralized film occur within the limits of C on the inner boundary of the film surface and $C = 0$ in the reaction zone. With such a concept of the impellent or dynamic factor, the absorption coefficient has the value of $K =$

$$\frac{D_2}{(1 - \alpha) d_f} \text{ which depends on the position of the reaction zone.}$$

Theoretically the location of the reaction zone in its turn depends upon the parameters of both phases; accordingly, the magnitudes of this dependency can be determined by assigning to coefficient K suitable values, which should exclude the effect of one respective phase.

$$K = \frac{1}{\frac{1}{H \cdot K_g} + \frac{1}{K_f}} \quad (2)$$

When the scrubber is operated on the counter flow principle the coefficients for all conditions of scrubber operation should be [4]:

$$K = \text{const} \frac{\left(\frac{1}{d}\right)^{1/2} \cdot \left[W \left(1 - \frac{U}{W}\right)\right]^{0.75} \cdot \gamma_g^{0.25}}{d^{0.25} \cdot \gamma_g^{0.75}} \quad (3)$$

$$K_f = \text{const} \frac{U^{1/2} \cdot \gamma_f^{1/6}}{\left(\frac{1}{d}\right)^{1/2} \cdot \eta_f^{5/6}} \quad (4)$$

where l is the height of the packing in meters,
 d the diameter of the packing in meters,
 U the migration rate of the absorbent in m/hour,
 γ the specific gravity in kg/m³,
 η the viscosity expressed in poises,
 H Henry's constant at atm mol/li,
 W the rate of gas flow in m/hour.

The constant H was computed from the value of the equilibrium constant of the reaction $K_2CO_3 + CO_2 + H_2O \rightarrow 2KHCO_3$, as the ratio between the partial carbon dioxide tension in the gas and its equilibrium concentration in the solution.

The purpose of this study was to determine the proportionality constants in equations (3) and (4), and to determine the effect of different factors on the kinetics of the absorption process. The experimental installation consisted of an absorption column 25.5 mm in diameter and a packing consisting of $8 \times 8 \times 2$ Raschig rings. The packing was 465 mm high. In the determination of the nominal coefficient K_f the effect of the gaseous phase was excluded by a 100% absorption of carbon dioxide. The experiments were made within a considerable range of fluid flow, ranging between 1.83 to 18.7 m/hour, in relation to the scrubber cross section at temperatures ranging from 16 to 30° C. The capacity of the absorbent varied from 1.45 to 2.8 mol/li.

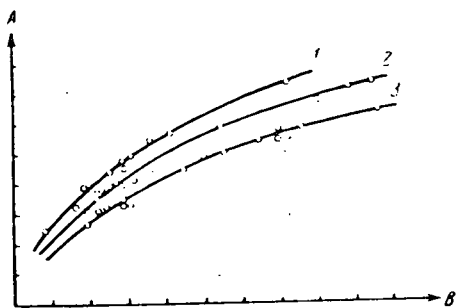


Fig. 2. Effect of liquid phase flow rate on the conditional coefficient K_{lg} .
Ordinate - conditional coefficient K_{lg} in kg/m²/hr.

Solution concentration (normality) and temperature in C° correspondingly: 1 - 1.8 and 16, 2 - 2 and 30, 3 - 2.85 and 20

Curves in Fig. 2 present the functional relationship (U) between coefficient K_f and the average rate of linear flow of the liquid phase.

Computed on the basis of equation (4) $K_f = U^{1/2}$; this is fully confirmed by the curves in Fig. 2. The effect of the absorbent's physical properties are accounted for

$$\text{by the equation } K_f = \frac{\gamma_f^{1/6}}{\gamma_f^{5/6}}$$

this is substantiated by the fact that the plots of all the experiments follow the course of a straight line which passes through the origin of the coordinates, as is shown in Fig. 3. This proves again that equation (4) holds true for the nominal coefficient K_f and that the proportionality constant was of a permanent value. The numerical value of the constant is equal to that of the tangent of the angle which the straight line curve formed with the abscissa, and amounted to 6.28×10^{-5} . Consequently, the final equation is:

$$K_f = 6.28 \cdot 10^{-5} \frac{U^{1/2} \cdot \gamma_f^{1/6}}{\left(\frac{1}{d}\right)^{1/2} \cdot \eta_f^{5/8}} \left(\frac{\text{KG}}{\text{m}^2 \cdot \text{hr} \cdot \text{mol/li}} \right) \quad (5)$$

This equation establishes the connection between the basic parameters of the liquid phase with the nominal coefficient of absorption.

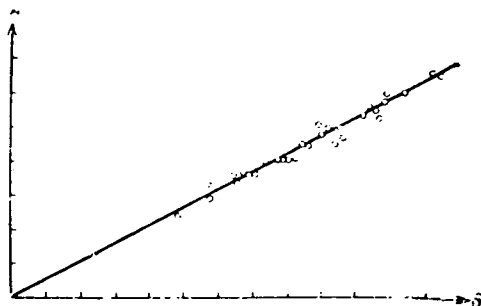


Fig. 3. Effect of liquid phase parameter on the conditional partial absorption coefficient K_{lk}

Ordinate - conditional partial coefficient K_{lk} in $\text{kg/m}^2/\text{hr} - \text{mol/li}$.

Abscissa - value of $U^{1/2} \cdot \gamma_f^{1/6} / \left(\frac{1}{d}\right)^{1/2} \cdot \eta_f^{5/6}$

Coefficient K_g can be computed as follows: the value of K is first determined experimentally for a diluted gas, and the value of K_f is known; accordingly, the value of K_g can be derived from equation (2).

$$K_g = \frac{K_f \cdot K}{H(K_f - K)}$$

The system under investigation does not operate

according to Henry's law, and in this connection the constant H changes with changes in concentrations of the reacting substance; accordingly, H varies with the height of the apparatus. All other conditions being the same, the nature of H changes with the height of the apparatus is such that their course belongs to a family of monotype curves; this makes it possible to obtain a sufficiently close definition of this magnitude from an analysis of one scrubber cross section. The most convenient cross section for this purpose is at the bottom of the scrubber, where the concentrations of the incoming gas and outgoing liquid are known. From the data thus obtained the value of constant H can be computed.

The functional relation between the conditional coefficient K_g along the gas film and the determinant parameters are shown as a straight line curve in Fig. 4. In the experiments the rate of gas flow (W) varied between 100 and 900 m/hour in relation to the free cross section of the apparatus; the concentrations of the absorbed carbon dioxide varied from 10 to 50 percent by volume, and the absorption temperature varied from 20 to 30°. The fact that the curve in Fig. 4 is a straight line shows that the functional relationship between coefficient K_g and its parameters was independent of the above mentioned factors.

The tangent of the slope of the straight line represents the mean value of the proportionality constant 2.55×10^{-6} . The effect of the gas phase upon the absorption coefficient can be determined by the following equation:

$$K_g = 2.55 \cdot 10^{-6} \frac{\left(\frac{1}{d}\right)^{0.5} \left[\frac{W}{d^{0.25} \cdot \eta_g^{0.75}} \left(1 - \frac{U}{W}\right) \right]^{0.75} \cdot \gamma_f^{0.25}}{\left(\frac{\text{KG}}{\text{m}^2 \cdot \text{hr} \cdot \text{atm}} \right)} \quad (6)$$

The absorption coefficient K can not be determined exactly without the knowledge of the nature of changes in the constant H as effected by the determinant parameters. Results of theoretical analysis indicated that the parameters referred to were the concentration of the gas which was being absorbed,

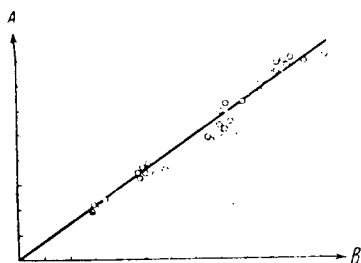


Fig. 4. Effect of gaseous phase parameter on the conditional partial absorption coefficient K_g .

Ordinate - conditional partial coefficient in $\text{kg}/\text{m}^2/\text{hr}/\text{atm}$.

Abscissa - value of

$$\left(\frac{1}{d}\right)^{0.5} \left[\frac{W}{d^{0.25} \cdot \eta_g^{0.75}} \left(1 - \frac{U}{W}\right) \right]^{0.75} \cdot \gamma_g^{0.25}$$

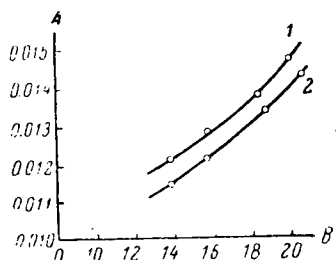


Fig. 5. Effect of gas concentration at 2N potassium carbonate solution at 25° on the constant of Henri.

Ordinate - const. H in $\text{atm}/\text{mol}/\text{li}$.

Abscissa - percent of CO_2 in the gas. Relative velocities W/U ; 1-80; 2-62.

the temperature, the relative rate of phase migration and the concentration of the absorbing solution.

Curves in Fig. 5 show the functional relationship between the constant H and the concentration of carbon dioxide absorbed from the gas. It can be seen that the absorption of a highly concentrated gas was accompanied by a corresponding increase in the value of constant H and an increase in the absorption coefficient. (The negligible changes in magnitude of $\frac{\gamma_g^{0.25}}{\gamma_g^{0.75}}$ of equation

(6) caused by increased concentration were disregarded). It should also be kept in mind that, as a rule, a rise in the gas concentration automatically increased the gas absorption capacity of the solution. The simultaneous increase in the indicated parameters invariably enhanced the intensity of the process.

The effect of temperature was

somewhat unique. With a rise in the temperature, K_f increased as the function of $\frac{\gamma_f}{\eta_f^{5/6}}$ the viscosity of which diminished faster than the specific gravity.

The value of K_g decreased insignificantly while constant H increased (see Fig. 6) and, as a consequence, the absorption coefficient increased.

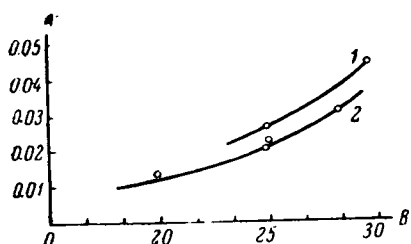


Fig. 6. Effect of temperature at 23% carbon dioxide in the gas on the constant of Henri.

Ordinate - constant of Henri
H in atm./mol./li.

Abscissa - temperature in $^{\circ}\text{C}$.
Relative velocity W/U and potassium carbonate concentration (normality) correspondingly: 1 - 50 & 1.8; 2 - 6.8 and 2.5.

On the other hand, with the rise in temperature the equilibrium constant of the absorption reaction increased, and the absorbing capacity of the solution decreased. Therefore, when the increase in the absorption coefficient was greater than the decrease in the solution absorption capacity, the rate of absorption increased, and vice versa. It follows that the effect of temperature on the absorption rate is different for different intervals of carbon dioxide concentrations in the gaseous phase, and of the salts in the liquid phase. The

latter can be computed by the methods previously described for the determination of constant H, and by using the equations for the determination of the conditional fractional coefficients K_f and K_g . The absorbing capacity of the solution is computed as suggested by Pozin [5]. Within the ranges of concentration and temperature of the present experiments, a rise in the temperature was accompanied by an increase in the absorption rate. Data obtained by these authors at higher temperatures showed that the maximum occurred at temperatures of the order of 50° , and that at higher temperatures the absorption rate decreased.

An increase in concentration of the chemisorbent lowered the value of constant H, as indicated by the curve in Fig. 7. At the same time, due to the rapid increase in the viscosity of the solution, the values of K_f and of the absorption coefficient K decreased. However, a decrease in the absorption coefficient does not necessarily mean that the absorption rate decreased. Since an increase in the chemisorbent concentration automatically resulted in an increase of the solution absorbing capacity, it follows that the resultant rate of the process was determined by the combined effects of the specified factors.

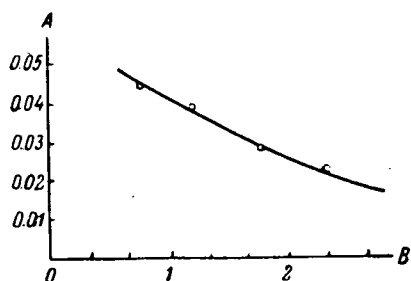


Fig. 7. Effect of potassium carbonate concentration at $W/U=88.5$, temp. 25° and 25% carbon dioxide in the gas on the constant of Henri.

Ordinate - constant H in atm/mol/li
Abscissa - solution concentration (normality).

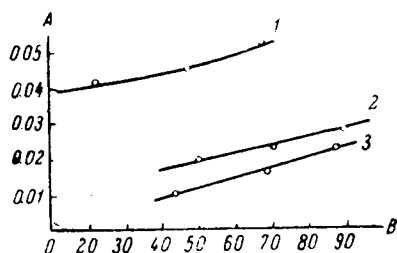


Fig. 8. Effect of relative migration velocity of phases W/U on the constant of Henri.

Ordinate - constant of Henri in atm./mol./li
Abscissa - relative velocity W/U .

This is substantiated by the experimental data, the plotted curve of which shows a conspicuous maximum corresponding to absorbing solution concentration approximating 150 g/li; higher concentrations markedly decreased the absorption rate.

The value of constant H is also appreciably affected by the relative migration rate of phases W/U , as is shown in Fig. 8. The value of H increased with an increase in W/U . At the same time, under conditions of a constant flow of the liquid, K_g increased; as a consequence the absorption coefficient K also increased. This increase continued until the value of $\frac{1}{HK}$ became negligible as compared with the resistance $\frac{1}{K_f}$, and a further increase in the rate of gas flow has no appreciable effect on coefficient K . Nevertheless, the value of K may be further increased by increasing the rate of liquid flow. Such a combination of the parameters makes possible the final selection of an optimal value for the absorption coefficient, by taking into consideration the cost of the absorbent and the limits beyond which scrubbers may become flooded.

In addition to increasing the value of K an increase in W/U enhanced the absorbing capacity of the solution by increasing the amount of gas in contact with a unit volume of the liquid phase. In fact, under above conditions absorption followed the same course as under the condition of a "highly concentrated gas". Simultaneous increase in the absorption coefficient and in the absorption capacity of the solution leads to the assumption that the W/U factor is highly effective in enhancing the course of the absorption process. This applies particularly to gases of high solubility. Because of their low liquid film resistance such gases create conditions for more effective utilization of the favorable increases in W/U .

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Coke Gas Purification from Hydrogen Sulfide in High Speed Rotary Absorbers.

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The sodium arsenite method for the purification of coke gas from hydrogen sulfide is now widely used. This study was undertaken for the purpose of intensifying the processes of hydrogen sulfide absorption and of sodium arsenite solution regeneration in high speed horizontally rotating absorbers. The experiments were carried out in a laboratory equipped with a large gas purifying installation using commercial coke gas intended for ammonia synthesizing plants.

Experimental part. The shaft of the horizontal absorber was equipped with stationary discs, each of which had 12 paddles set at an angle. The absorber shaft was connected directly with a motor, the speed of which was controlled by a slide rheostat. The experimental installation is shown in Fig. 1.

Sodium arsenite solution from container 1 was fed into absorber 2 by gravity. The level of the liquid was maintained at 0.25 the height of the absorber diameter. The spent solution was run into receiving tank 3. Coke gas from cylinder 4 entered absorber 2 at the lower part of its end wall and came out at the other end of the absorber through an outflow pipe connected with a drop separator 5, equipped with an overflow pipe 6 which in turn was connected with the absorber. From the drop separator 5 the gas entered absorbers 7 connected in series; the absorbers 7 were partially filled with a 3% solution of zinc

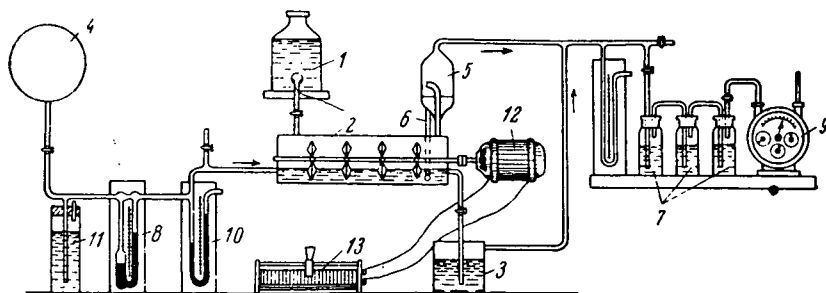


Fig. 1. Plan of the experimental setup

1 - Small pressure tank; 2 - mechanical absorber; 3 - ass-
embler; 4 - collector; 5 - drip drain; 6 - overflow pipe;
7 - glass absorbers; 8 - flow meter; 9 - gas meter; 10 -
manometer; 11 - monostat (level control?); 12 - motor;
13 - sliding flow meter.

acetate which absorbed the residual coke gas. The series was made of a number of absorbers sufficient to absorb the entire residual coke gas. Additional two flasks served as controls. The rate of gas flowing into the horizontal rotary absorber was controlled by flowmeter 8 and gas recorder 9. The gas pressure at the points of entrance and exit was indicated by manometers 10, and pressure constancy was maintained by monostat 11. The H_2S content was determined by the zinc acetate method. The zinc acetate solution was treated with a 0.1 N iodine solution to the appearance of an orange color, followed by starch, which turned the solution black; it was then titrated with an 0.1 N solution of hyposulfate.

Studies were made of the effect of the hydrodynamic, as well as the physico-chemical conditions on the absorption rate. The effect of the hydrodynamic factors was studied with reference to the construction of the discs, their peripheral velocity, the volume rate of the gas flow, and the height (volume) of the liquid in the horizontal absorber, and the rate of the horizontal movement of the liquid in the absorber. The effect of the physico-chemical factors was studied with reference to temperature, chemical absorption capacity of the solution and the H_2S concentration in the gas. The greater number of experiments was carried out with a sodium arsenite solution containing 8.4 g/li As_2O_3 , and the solution pH = 7.9 - 8.1. The effect of As_2O_3 concentration on the absorption rate was studied in a special series of experiments.

The effect of peripheral velocity and the construction of discs upon the rate of absorption. Results of the experiments indicated that the construction of the discs played an important part in the creation of optimal hydrodynamic conditions. Three different shapes of paddles marked respectively a, b and c, shown in Fig. 2 were studied. All the a-type disc paddles were bent in the same direction at an angle of 15° . The b-type disc paddles were bent toward one another in an alternate fashion.

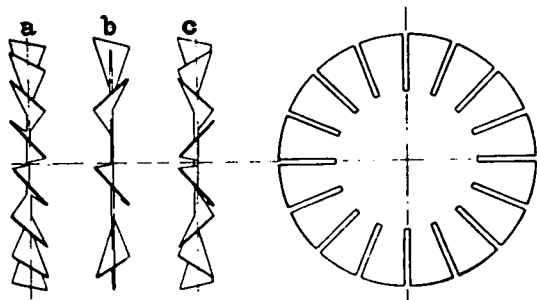


Fig. 2. Disc construction.
a - all blades at unidirectional angles;
b - every other pair of blades at opposing
c - each successive pair of blades at opposing angles.

All c-type disc paddles were bent toward one another, and the discs were fastened to the shaft so that the concave sides of the paddles faced each other. Results showed conclusively that the c-type discs produced hydrodynamic conditions most favorable to the highest rate of absorption.

The peripheral velocity of the discs played the principal part in the intermixing of the liquid and the gas. With the increase to the optimal peripheral velocity of the disc rotation, the absorption rate steadily increased. A peripheral velocity exceeding the optimal lowered the absorption rate. Results obtained from an investigation of the effects of peripheral velocity and of the disc construction on the absorption rate are shown in Fig. 3. The data show that with an increase in the number of revolutions of the shaft to 2000 per minute and with $v_g = 8.6$ m/sec, the rate of H_2S absorption increased rapidly due to the disruption of the diffusion films and the convection movement of the materials. At $n = 1700 - 2300$ revolutions per minute the rate of the process became stabilized, indicating the presence of most favorable hydrodynamic conditions in the apparatus. Further increase in the number of revolutions of the discs increased the centrifugal force and threw the liquid against the walls of the apparatus; simultaneously, the gas concentration in the liquid became lowered as a result of which the contact surface between the two phases was diminished; together these two phenomena brought about a reduction in the absorption rate.

Experimental results also indicated that irrespective of the peripheral

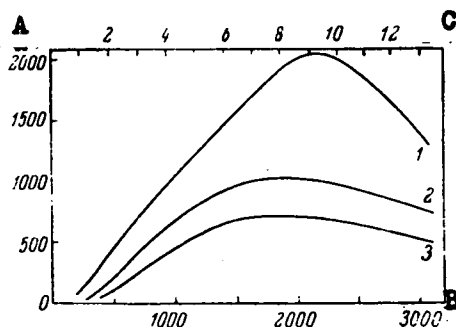


Fig. 3. Effect of peripheral disc velocity (number of shaft revolutions) and of disc construction on the absorption coefficient K .
 $w = 400 \text{ m}^3/\text{hr}$; $\phi = V_{lg}/V_a = 0.25$; $t = 24-26^\circ$;
 $c_{lg} = 8.4 \text{ g/li}$; $\text{pH} = 8.0$.
 A - coefficient of absorption K_g in $\text{kg H}_2\text{S}/\text{m}^3/\text{atm}$.
 B - Peripheral disc velocity; C = No. of shaft rpm.
 Disc construction: 1-c; 2-b; 3-a; (see Fig. 2).

velocity of the discs, the absorption rate depended to a considerable extent on the construction of the discs. The highest absorption rate was attained with discs of type c. In this case foam and spray were formed between the discs; a thick layer of active foam with bubbles of 1 to 2 mm in diameter was formed over the liquid;

at optimal peripheral disc velocity a gas-liquid emulsion was formed in the apparatus. The highest absorption rate was attained under the latter conditions.

The effect of the volume of liquid in the apparatus. Strict maintenance of a constant volume of liquid in the apparatus was an important condition for the normal operation of the installation. The amount of liquid in the apparatus was one of the basic hydrodynamic factors affecting the rate of the process.

An investigation of the effect of volume of the liquid in the apparatus was made under the following constant conditions: $w_{sr} = 263 \text{ m}^3/\text{m}^3/\text{hour}$, $t = 25 - 26^\circ$, $c_{eg} = 8.4 \text{ g/li}$, $\text{pH} = 8.1$, $x_1 = 1.51 - 1.58\% \text{ H}_2\text{S}$ in the gas. Discs type c and type a, at 2175 and 2900 revolutions per minute respectively, were used in this investigation. The results of these experiments are plotted in Fig. 4.

The curves show that the highest absorption rate corresponded to a volume of liquid filling 25 - 30% of the absorber capacity. A lower level of the liquid resulted in a lower concentration of gas in the liquid and a reduced contact surface between the two phases. Filling of the apparatus with the liquid above 30% of its capacity completely disrupted the operational system of the apparatus and lowered considerably the rate of gas absorption.

The effect of volume rate gas flow. The volume rate gas flow determined the efficiency of the apparatus and was one of the most important factors

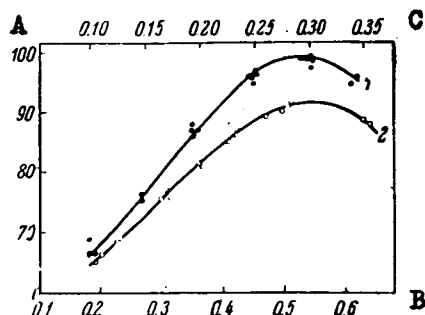


Fig. 4. Effect of absorber load ($\phi = V_{lq}/V_a$) on the amount of H_2S absorbed (α). For conditions of the experiment see text above. A - α in percent; B - values of ϕ ; C - absorber load.

Type of disc and n -shaft r.p.m. correspondingly:
1 - disc c, $n=2175$; 2 - disc a, $n=2900$.

per minute. The time required for the liquid to pass through the apparatus was one minute.

The volume rate of gas flow ranged between 100 and 700 m^3/m^3 per hour and temperature between 25 and 42°. Plots of the results of this investigation are shown in Fig. 5 and Fig. 6.

The curves indicate that the rate of H_2S absorption in the apparatus equipped with discs of type a rapidly decreased with an increase in the volume rate of gas flow. With $w = 400 m^3/m^3$ hour the absorption rate was only 66%. With discs of type c any increased volume rate of gas flow gradually decreased the absorption rate.

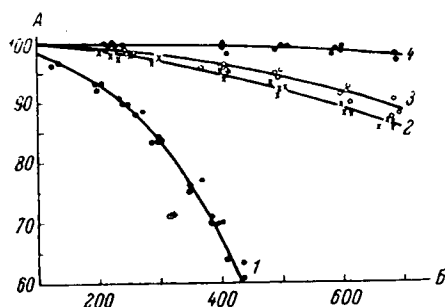


Fig. 5. Effect of gas volume velocity (w) on the degree of hydrogen sulfide absorption (α). $n = 2175$; $\phi = 0.25 - 0.30$; $t = 24^\circ$; solution concentration = 8.4 g/li; pH = 8.1. Ordinate - α in %; abscissa - w in $m^3/m^3/hr$. 1 - $t=24^\circ$, disc a; 2 - $t=24^\circ$, disc c; 3 - $t=30^\circ$, disc c; 4 - $t=42^\circ$, disc c. (For disc types see Fig. 2).

controlling its hydrodynamic conditions, and consequently, the absorption rate. Investigations of the effect of volume rate gas flow were carried out under the following constant conditions: $V_f = 0.28V_a$, pH = 7.9 - 8.1, $s_f = 8.4$ g/li of solution, and $x_1 = 1.3 - 1.4\%$ H_2S . Type a and type c discs were used in the experiments, with $n = 2175$ revolutions

The experimental data showed that at a temperature of 40° to 42° discs of type c effected almost complete H_2S absorption with w ranging between 400 and 500 m^3/m^3 hour. The effect of the volume rate of gas flow on the absorption coefficient simulated that of the peripheral velocity of the discs.

Gradual increase in the volume rate of the gas flow

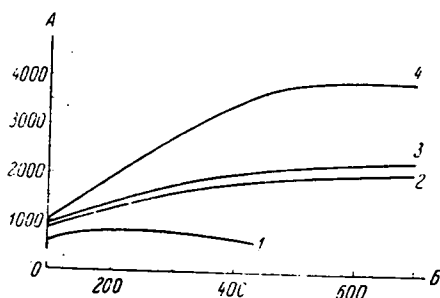


Fig. 6. Effect of gas volume velocity (w) on the absorption coefficient (K).
 $n = 2175$; $\phi = 0.25 - 0.80$; $t = 24^\circ$; solution concentration = 2.4 g/li ; $\text{pH} = 8.1$.
 Ordinate- K_g in $\text{kg H}_2\text{SO}_4/\text{m}^3/\text{hr}$. Abscissa- w in $\text{m}^3/\text{m}^3/\text{hr}$.
 Temperature in $^\circ\text{C}$ and disc type:
 1 - 24° , a; 2 - 24° , c; 3 - 30° , c; 4 - 42° , c.
 (For disc types see Fig. 2).

to the point of optimum rapidly increased the absorption rate until it reached a definite maximum. An increase in the volume rate of the gas flow was accompanied by an increased rate of the linear gas flow in accordance with the following equation.

$$\omega_{\text{lin}} = \frac{w \cdot V_a}{3600 \cdot f_{\text{sv}}}$$

where f_{sv} is the free cross section of the apparatus, and V_a is the volume of the absorber.

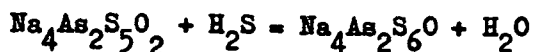
A reduced linear rate of gas flow lowered the turbulence effect of the system. According to available data, the optimal linear rate of gas flow remained within the limits of 0.8 and 2.5 m/sec, at which the absorption rate was highest.

The effect of physical and chemical factors upon the rate of absorption.

The basic physical and chemical factors which determined the rate of absorption were temperature, As_2O_3 concentration in the solution, and H_2S concentration in the gas.

The study of the effect of temperature upon the absorption rate was carried out under the following constant conditions: $w = 400 \text{ m}^3/\text{m}^3 \text{ hour}$, $n = 2200$ revolutions per minute, concentration of H_2S in gaseous phase $x = 1.26 - 2.26\%$ and a concentration of $\text{As}_2\text{O}_3 = 8.4 \text{ g/li}$. The pH value of the operating solution before H_2S absorption was within the limits 7.9 and 8.1, but the pH after absorption decreased and was within the limits of 7.5 and 7.55. The experimental data are shown in Fig. 7 and Fig. 8.

The curves show that temperature rise up to 40 or 42° increased the absorption rate, which may have been due to an acceleration in the reaction between H_2S and oxy-sulfo-arseno-sodium salt, according to the following equation:



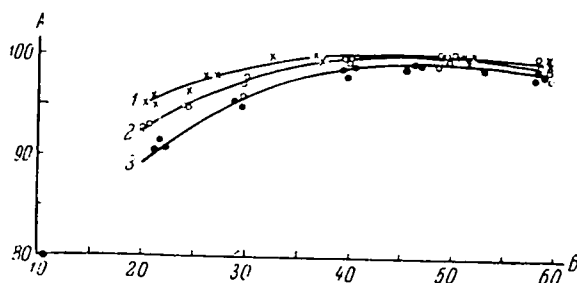


Fig. 7. Effect of temperature (t) on the degree of hydrogen sulfide absorption (α).

$V_g = 9.4$ m/sec.; $n = 2200$; $w = 400$ m³/m³/hr; $\phi = V_{lg}/V_a = 0.30$; C_{lg} = soln. concn. = 8.4 g/li; pH = 8.0

Ordinate - α in %; abscissa - t in °C.
Hydrogen sulfide concentration in the gas as it enters the absorber, in % = x_1 ; 1 = 1.82 - 2.26; 2 = 1.57; 3 = 1.26 - 1.32.

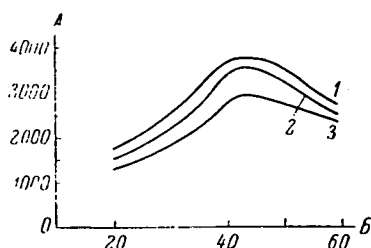


Fig. 8. Effect of temperature (t) on the coefficient of absorption (K_g).

Ordinate - K_g in kg/m³/hr/atm.

Abscissa - t in °C.

x_1 as in Fig. 7: 1=1.82-2.26; 2=1.58; 3=1.2622-1.3208.

A temperature rise above 42° lowered the rate of absorption consequent to an increase in the H₂S tension and an accompanying decrease of the absorption motive force. The experimental data show that the optimal temperature for the process ranged between 40 and 42°.

The next important fact affecting the rate of the process was

the concentration of As₂O₃ in the solution. The experimental results showing absorption rate of H₂S by a sodium arsenite solution containing 17.38 g/li of As₂O₃ are listed in the Table below.

Degree of H₂S absorption at liquid saturation = 17.38 g/li As₂O₃ using b-type discs.

Gas vol. velocity m ³ /m ³ /hr	n r.p.m.	v_g periper. velocity m/sec.	Ratio of absorber sol/vol. of drum V_{lg}/V_{ldr}	Temper. t in °C	% of H ₂ S in gas		α % of absorption
					x_1 at intake	x_2 at outflow	
421	1850	7.9	0.30	30 - 32	1.2487	0.0	100
525	2000	8.6	0.30	30 - 32	1.2487	0.0	100
630	2000	8.6	0.30	30 - 32	1.2487	0.0025	99.8
720	2000	8.6	0.30	30 - 32	1.2487	0.0037	99.7

The listed data show that traces of H_2S were present at volume rates of gas flow above $600 \text{ m}^3/\text{m}^3$ hour, indicating that a content of As_2O_3 equalling 17 - 18 g/li brought about a high efficiency and the complete absorption of H_2S at volume rates from 500 to $550 \text{ m}^3/\text{m}^3$ hour.

The effect of an H_2S concentration in the gaseous phase upon the absorption rate was studied within the narrow limits of 1.26 to 2.26% of H_2S . The experiments were carried out under the following conditions: $w = 400 \text{ m}^3/\text{m}^3$ hour, $v_g = 9.4 \text{ m/sec}$, absorber liquid $\phi = 30\%$ of capacity and discs of type c. The interpolated data are shown in Fig. 7. It follows that the absorption rate increased with higher H_2S concentrations in the gaseous phase. The difference for various absorption rates was particularly manifest at relatively low temperatures.

The technological and the economical aspects of the proposed method. A comparison of the productivity of reaction volumes in packed towers with the rotary apparatus described, revealed that under similar conditions of operation the rotary apparatus was at least 25 to 27 times more efficient. It follows that for similar productivity the required volume of the rotary apparatus can be 25 to 27 times smaller than that of the towers. The metal required for the construction of a rotary absorption apparatus is only 8 to 10% of that required for tower construction.

In comparing the operational expenses of a tower system with those of a rotary apparatus, it should be noted that they are about the same except for the consumption of electric power. The electric power is used principally in feeding of the absorbent solution into the apparatus and in aspirating the gas. On the assumption that the required solution volume is 350 m^3 per tower, a four-tower system would require a minimum motor power of 360 kilowatts for its operation. The power necessary for the gas aspiration through the towers for removal of sulfur is determined by the pressure drop of the entire system: in the existing tower installations the pressure drop is never less than 1000 mm of water requiring a power of 220 kilowatts. Accordingly, the total consumption of electric power in the modern installations amounts to 570 kilowatts.

In the rotary absorbers the liquid is raised to a height not exceeding 5 meters, wherefrom it is fed by gravity. In this case the required motor power does not exceed 4.5 kilowatts. The maximal pressure drop of a rotary absorber system varies between 100 to 200 mm of water, therefore, the power required for the gas aspiration is approximately 44 kilowatts. Rotation of the working

parts of the rotary apparatus requires an additional 40 kilowatts per apparatus [1].

Consequently, the total required electric power for the operation of a rotary apparatus amounts to 248.5 kilowatts, or about 2.5 times less than is required for the operation of the tower system.

Conclusions.

1. The results of the investigation indicated that the absorption rate of H_2S by sodium arsenite solution in a high speed rotary absorber was considerably greater than in tower systems.

2. H_2S absorption in a rotary apparatus requires considerably lower reaction volumes, less metal, smaller capital investment and less electric power for its operation.

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Oxidation of Ammonium Sulfite-Bisulfite Solutions in the Recovery of SO_2 from Smoke Gases.

By

B. A. Chertkov.

Zhurnal Prikladnoi Khimii, Vol. 32, No. 5, 960-965, 1959.

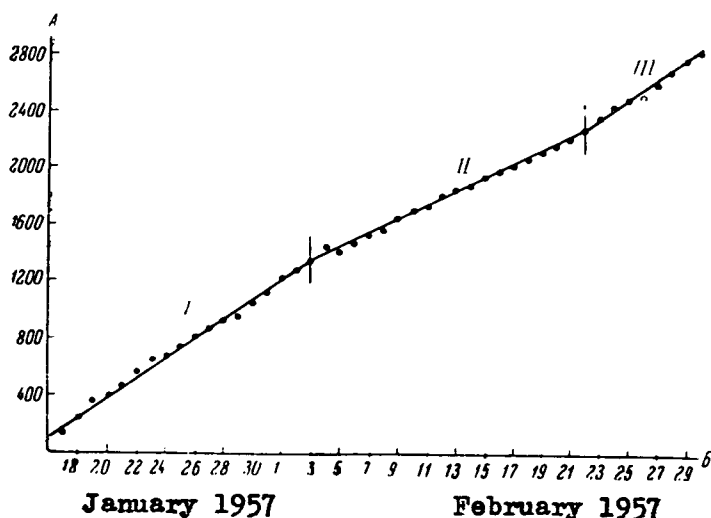
Previous reports [1 - 3] dealt with the effect of different factors, such as the solution composition, temperature, etc., on the rate of ammonium sulfite-bisulfite oxidation. Results showed that an increase in the relative concentration of bisulfite in the solution (S/C ratio), in the temperature, and in the partial oxygen tension in the gaseous phase increased the degree of oxidation in the solution, and that at a definite concentration of sulfite-bisulfite, oxidation attained a maximum rate which abated above or below that optimal concentration. It was determined simultaneously that the oxidation

reaction was notably accelerated under the catalytic effect of added ammonium thiosulfate, which in time accumulated in the solution, and that the introduction of an inhibitor, such as n-phenylenediamine, stopped the action of thiosulfate and markedly arrested the oxidation reaction. However, the presence of solid impurities in the solution particularly of fly-ash coming from smokestacks sharply counteracted the effect of the inhibiting substance. Under practical operating conditions of gas-purifying installations hydrodynamic factors came into play along with the above-enumerated factors, so that the total oxidation effect of the absorber solution became a complex function of a series of variable values.

The experimental results and the theoretical relationships (ratios) derived from them were compared with the actual oxidation process of ammonium sulfite-bisulfite solution under industrial conditions. This was done in a case of working solution oxidation in an installation for the recovery of SO_2 from smokestack gases by the cyclic ammonium process [4].

Ammonium sulfate $[(\text{NH}_4)_2\text{SO}_4]$, the product of ammonium sulfite-bisulfite oxidation was extracted from the solution and used as a fertilizer. The details of the technological process of SO_2 recovery from emission gases by the cyclic ammonium method will not be discussed in this paper; however, it should be pointed out that the removal of the accumulated ammonium sulfate was accomplished by vacuum condensation of the working solution, which caused the falling out of solutions of the least soluble ammonium sulfate; final removal of the latter was attained by centrifugation.

In an ideal cyclic process the quantity of crystalline $(\text{NH}_4)_2\text{SO}_4$ obtained during a given time interval can serve as an indicator of the reaction rate of the absorber solution oxidation. Under conditions of actual production losses of solution occur which to some degree reduce the amount of ammonium sulfate. Such losses can be determined with a high degree of accuracy from the amount of ammonia used by the installation. On the basis of the quantity of crystalline $(\text{NH}_4)_2\text{SO}_4$ obtained and the quantity lost in the production cycle, and by analytically determining the change in the $(\text{NH}_4)_2\text{SO}_4$ of the working solution in a unit time, it is possible to determine the total amount of ammonium sulfate formed as a result of the absorber solution oxidation in the course of SO_2 absorption from the gas. Such quantitative accounts of ammonium sulfate formation were computed for different operational stages of the purifying installations. Results of one such computation are shown in the following Figure.



Increasing total amount of ammonium sulfate formed in the system.

A - Total amount of ammonium sulfate in the system in kg-mol; B - Number of days

Average rate of ammonium sulfate formation according to periods in kg-mol/day:

I - 65.0; II - 49.5; III - 67.5

The curve in the Figure shows that the process of working solution oxidation of a given installation, generally speaking, followed an even course. During long time intervals and specific conditions of absorber operation, the average rate of $(\text{NH}_4)_2\text{SO}_4$ formation was constant. Quantitative data on working solution oxidation and on the working conditions of the absorbers at all investigated periods are presented in the following Table. In addition to the

average $(\text{NH}_4)_2\text{SO}_4$ increase during 24 hours, correspondingly equivalent rates of oxygen absorption by G_{O_2} are presented in $\text{g/m}^2/\text{hour}$, in relation to the surface unit (area) of the absorber packing.

The data in the Table show that during the first three work periods of the sulfur-catching installation, oxidation proceeded at highest intensity and the value of G_{O_2} reached $1.1 \text{ g/m}^2/\text{hour}$. This was due to higher temperatures of the absorber solution as well as to the higher content of fly-ash, which counteracted the effect of the reaction inhibitor. Low oxidation rate during the fourth work period of the installation was due to the low thiosulfate concentration and low fly-ash content in the solution. The fact that the saturated solution flowing out of the absorber had a lower S/C ratio than during other periods was also of importance. Increased rate of solution oxidation during the fifth period, in addition to the above mentioned reasons, was due largely to the fact that during this period the absorber solution was saturated to a higher S/C ratios than during the preceding periods. During subsequent work periods of the installation, the temperature solution in the absorbers was considerably lower, causing reduction in the oxidation rate despite the notable increase in the thiosulfate content of the working solution. During

Results of working solution oxidation in the operation of the sulfur catching installation

Periods of installation work	Dates	Properties of the working solution							Outflowing solution temperature	Average $(\text{NH}_4)_2\text{SO}_4$ gain, kg/mol/day	Number of working absorbers	CO_2 g/m ³ /hour	Remarks
		Content in mol/li			Ash in g/li	Top layer S/C in drum	Bottom layer S/C in drum						
		Total NH_3	NH_3 ef	$(\text{NH}_4)_2\text{SO}_4$									
1	25 III — 13 V 1952	7.25	3.6	0.06—0.25	8.3	0.79	0.88	38—30	41.0	1	0.91	During all the periods the linear velocity of the gas through the total drum cross-section equalled 1.1 - 1.3 m/sec; moisture density - 4.0—4.5 m ³ /m ² /hr; absorber packing area - 30000 m ² ; SO ₂ content in smokestack gas was 0.3 - 0.4%; O ₂ content range was 8 - 12%; inhibitor range in solution was 0.5 - 1.5 g/li.	
2	15 IX — 10 XI 1952	8.25	4.0	0.03—0.10	3.5	0.79	0.89	35—35	35.5	1	0.79		
3	29 XI — 7 I 1952	6.8	3.2	0.03—0.10	4.5	0.80	0.90	35—34	49.5	1	1.11		
4	30 VIII—12 IX 1953	5.0—8.0	2.5—5	0.01—0.04	1.1	0.78—0.82	0.83—0.90	28—40	22.5	1	0.50		
5	12 IX — 27 IX 1953	7.0—9.0	2.8—4.5	0.04—0.07	2.3	0.78—0.82	0.87—0.96	28—38	55.5	1	1.24		
6	6 XI — 13 XI 1955	2 — 7.5	1 — 4.8	0.01—0.07	1.05	0.79—0.82	0.9 — 0.92	18—28	34.3	2	0.38		
7	13 XI — 30 XI 1955	7.5—9.7	3.3—4.5	0.07—0.29	1.85	0.79—0.82	0.93—0.96	17—24	78.8	2	0.88		
8	30 XI — 22 XII 1955	9.5	2.7—4.3	0.29—0.42	2.0	0.79—0.82	0.90—0.96	23—28	63.7	2	0.71		
9	22 XII — 28 XII 1955	9.5—10	2.9—4.3	0.42—0.52	1.9	0.79—0.82	0.91—0.96	23—26	70.0	2	0.78		
10	16 I — 3 II 1957	7.0—9.5	3.4—4.6	0.10—0.26	1.94	0.79—0.82	0.92—0.95	20—22	65.0	2	0.72		
11	3 II — 22 II 1957	9.5	3.7—4.6	0.26—0.35	2.0	0.79—0.82	0.86—0.96	21—24	49.5	2	0.55		
12	22 II — 2 III 1957	9.5	3.6—4.2	0.35—0.34	3.12	0.79—0.82	0.95—0.96	20—22	67.5	2	0.75		
13	12 III — 3 IV 1957	9.0	3.5—4.1	0.15—0.27	2.03	0.79—0.82	0.93—0.97	20—22	72.4	2	0.80		

the sixth period the reduced oxidation rate was due to the low total salt concentration in the solution at the beginning of the period (solution accumulation) and to the low thiosulfate content. If this be temporarily excluded from consideration, then it will be seen that in the following seven periods the average rate of solution oxidation fluctuated within a limited range and corresponded to an average oxygen absorption rate of $0.75 \text{ g/m}^2/\text{hour}$.

The absorber operating conditions listed in the preceding Table for the latter periods were specific for SO_2 recovery from smoke gases by the cyclic ammonium method. If this be taken into consideration, then $0.75 \text{ g/m}^2/\text{hour}$ can be reliably accepted as the specific rate of ammonium sulfite-bisulfite solution oxidation under industrial conditions. Changes in any of the conditions of SO_2 absorption from smokestack gases can affect the solution oxidation rate in several ways. Changes in the percent content of SO_2 in the gases cannot alone affect the rate of the solution oxidation; however, in the cyclic process each SO_2 concentration in the gas is accompanied by a specific optimum solution composition [5]; therefore, change in the percent SO_2 content in the gases will automatically effect a change in the solution's composition. Changes in the percent content of oxygen in the smokestack gases, for example, during the change over to SO_2 absorption from non-ferrous discharge gases, must result in a proportional change in the G_{O_2} value [2]. The change in linear velocity of the gas in the absorber cannot affect the rate of solution oxidation, due to the fact that in absorption of oxygen, which is a poorly soluble gas, the basic role is played by the resistance of the fluid film, and the resistance of the gaseous film can be ignored.

Increase in the absorber moisture density lowers the resistance of the fluid film and enhances the oxygen migration from the limiting film into the deeper layers of fluid. On the other hand, since the general oxidation process is controlled by the relatively slow reaction between sulfite-bisulfite and dissolved oxygen, the concentration of the latter in the fluid phase is apparently insignificant, and the effect of moisture density for any case can be accepted as similar to that prevailing in simple physical absorption. According to V. M. Ramm [6], the coefficient of mass transmission in fluid film (K_f) is an exponential function of the humidity (H), the power of which can vary from 0.33 (in film absorber) to 0.67 (in packed absorber). Thus, the effect of hydrodynamic factors can be manifested only if the moisture density

of the absorber is considerably increased. However, this condition may not arise where the solution in the absorber sections is recirculated. The unimportant role of hydrodynamic factors is confirmed also by the fact that the $0.75 \text{ g/m}^2/\text{hour}$ average rate of oxygen absorption in the absorber approximates the value obtained in laboratory studies of oxidation processes under static conditions [3].

Change in salt concentration can have different effects on the process of oxidation. Increase in NH_3_{sum} and NH_3_{ef} concentrations above the values indicated in the Table will perforce increase the oxidation rate due to the lowering of oxygen solubility in more concentrated salt solutions. A lowering in NH_3_{ef} concentration will at first increase the rate of oxidation to a maximum of 2.5 mol/li of NH_3_{ef} , after which it will sharply decrease due to the fact that the role of oxygen intake as the limiting factor will be taken over by the reaction rate between sulfite-bisulfite and dissolved oxygen [1]. However, in the cyclic process of SO_2 recovery from smokestack gases, the use of low dilution is precluded. Increase in the thiosulfate content of the solution, for example to 0.5 mol/li , can by itself cause a sharp increase in the rate of the solution oxidation [1]. However, in the presence of a sufficient quantity of inhibitor (1 g/li), the catalytic action of thiosulfate is suppressed, so that this factor can be disregarded. From this viewpoint, the increase in fly-ash content is undesirable, because it weakens the action of the added inhibitors.

Change in S/C ratio of the saturated solution can noticeably affect the speed of oxidation only when the variation range of this ratio is a wide one [1]. In the normal cyclic process the S/C ratio of saturated solution in the case of any initial SO_2 concentration in the smokestack gas approaches the theoretically possible limit (for pure bisulfite $\text{S/C} = 1$); accordingly, the effect of this factor is limited to a relatively narrow area in which changes in oxidation rate play a comparatively unimportant role. Rise in absorber solution temperature must also have an accelerating effect on the oxidation process [2]. Summing up the above, it can be concluded that in changing the conditions of SO_2 absorption from smokestack gases most potent effects on the oxidation process will be produced by partial oxygen pressure in the gas, ammonium sulfite-bisulfite concentration in the solution, S/C ratio in the resulting saturated solution and the temperature of the absorber solution.

It was shown [1, 2] that the effects of the enumerated factors can be determined quantitatively with the help of previously established functional factors; this should make possible the determination of the oxidation degree in any case of SO_2 absorption from smokestack gases by the cyclic ammonium method under any absorber operating conditions, by taking as the initial value the average rate of solution oxidation in the purification installation under investigation. The quantity of sulfate formed as a result of reagent oxidation in any method of SO_2 absorption from gases is usually compared with the total amount of SO_2 absorbed during a unit time. The degree of oxidation thus derived is a relative value which depends on the SO_2 concentration in the gas and the total gas load in the absorber. It can be seen that, as the total quantity of SO_2 absorbed in the absorber increased, the degree of oxidation was lowered, provided that other conditions remain the same. The hydrodynamic factors play no prominent role in the oxidation of the working solution, yet they affect substantially the rate of SO_2 absorption; therefore, lowest degree of oxidation will take place in the absorber under conditions of most intensive SO_2 absorption.

From this point of view intensive bubbling of the gas through a foam type absorber should be preferred to the use of a packed absorber. Results of previous investigations indicated [7] that the speed of SO_2 absorption from smokestack gas in an experimental bubble-foam absorber was 10 - 15 times as effective as in the packed absorber and that the oxygen absorption rate rose only 2 - 3 times. As a result, the degree of oxidation was about 5 times lower than under analogous conditions in a packed absorber. Thus, replacing packed absorbers by bubbling foam absorbers, in addition to other advantages, will make possible SO_2 recovery from gases with low SO_2 content by the cyclic ammonium method; this will reduce the rate of $(\text{NH}_4)_2\text{SO}_4$ formation and will result in a lower consumption of ammonia.

It may also make unnecessary the use of the relatively expensive oxidation reaction inhibitor, n-phenyldiamine.

Conclusions.

General concepts were derived from practical data on oxidation of ammonium sulfite-bisulfite solutions in the process of SO_2 recovery from smokestack gases in packed absorbers. The average rate of oxygen absorption from gas (G_{O_2}) was determined under specific conditions of the cyclic ammonium method;

limits of possible value fluctuations were studied under changing absorber operating conditions. Attention was called to the possibility to considerably decrease the degree of SO_2 oxidation by using a bubbling foam type of absorber.

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Carbon Dioxide Absorption by Sodium Hydroxide Foam.

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Zhurnal Prikladnoy Khimii, Vol. 3, No. 5, 1011-1018, 1957.

Sodium hydroxide solutions have been used widely in low temperature cooling of synthetic ammonia for its fine purification and in many other processes which require almost complete purification of gases from carbon dioxide. The equipment used in such gas purification processes consists of either bulky packed scrubbers or of foam type gas purifiers. Previous reports on the absorption of carbon dioxide and other gases by 3 N NaOH solution at 60° [1] in a foam apparatus [2 - 7], showed that absorption of carbon dioxide by an alkaline solution was more effective in foam apparatus than in a scrubber or bubbling apparatus. In connection with the above, it was of interest to establish the optimal conditions for the absorption of CO_2 in a foam apparatus. Knowledge of the chemistry and mechanism of the process and its rate under different conditions is still lacking.

The mechanism of the process depends on the conditions of the CO_2 diffusion in the gaseous or liquid phase, the reaction products at the contact surface and at different depths of the thin mass of the liquid, and also on

the hydroxylions in the reaction zone [8]. The formed carbonate differs from sodium hydroxide in its solubility in water, in the rate of its reaction with CO_2 , the rate of its diffusion, etc. The poor solubility of CO_2 in the surface layer of the liquid (carbonate) retards the diffusion of the absorbate component from the gaseous phase. The available reports on CO_2 absorption by NaOH solutions [8 - 14] under different conditions present conflicting results and offer diverse explanations for the mechanism of action. Therefore, the reports cannot serve as reliable criteria in the selection of optimal conditions of temperature and solution concentration for use in the experimental testing of foam apparatus.

The purpose of the present work was to investigate the rate of CO_2 absorption by NaOH solution in a foam apparatus under different physical, chemical, and hydrodynamic conditions, such as CO_2 concentration in the gaseous phase, NaOH concentration in the solution, temperature, linear rate of gas flow, the rate of liquid flow, etc. The experimental data obtained related to the rate and completeness of carbon dioxide absorption by a solution of sodium hydroxide in a foam apparatus under various conditions. The absorption data presented below were obtained from experimental absorption of carbon dioxide by a solution of sodium hydroxide, in a previously described type of foam apparatus [1]. Fig. 1 shows the functional relationship between absorption coefficient (K) in the case of 1 m^2 of the apparatus shelf screen and also of the efficiency coefficient (η) of a single shelf screen of the apparatus and the initial concentration of CO_2 in the gas (C_{in}). Methods for the calculation of K and η were described on several previous occasions [1 - 7]. The conditions under which the experiments were performed at any stage of the investigation are specified in the legends accompanying text Figures 1 to 9, inclusive.

It was demonstrated that all other conditions being the same, the value of K was independent of C_{in} within change limits 2 to 15%. This indicated that under such conditions the rate of absorption was controlled by the resistance of the gaseous phase. The value of η slightly increased with the increase in C_{in} . This may be due to a decrease in the linear velocity (w) of the unabsorbed component of the gaseous mixture, as the value of C_{in} increased, since the magnitude of (η) increased with the decrease in (w).

The functional relationship between the indexes of carbon dioxide in a foam apparatus and NaOH solution concentration is shown in Fig. 2. The curves

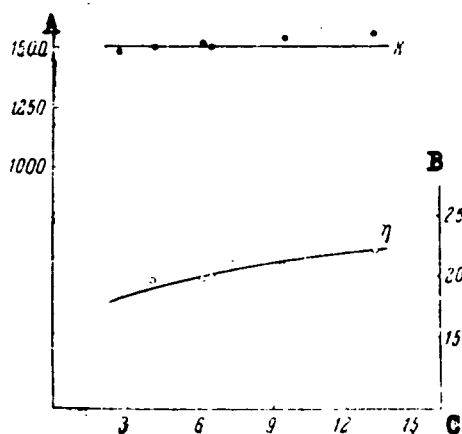


Fig. 1. Effect of carbon dioxide concentration on K and η .

A - Absorption coefficient (K) in $\text{kg/m}^2/\text{hr} \times \text{kg/m}^3$; B - degree of absorption (η) in %; C - original concentration of carbon dioxide in the gas (C_{volx}) in volume %.

Screen 5/2. Rate of gas flow $w = 2.0 \text{ m/sec.}$; intensity of liquid phase flow $i = 5 \text{ m}^3/\text{m/hr}$; height of weir $h = 100 \text{ mm}$; 3 N solution of sodium hydroxide; $t = 60^\circ$.

show that an increase in NaOH concentration from 0.25 N to 2 N resulted in increased values of the absorption coefficient and the rate of CO_2 absorption efficiency coefficient. This can be explained by the fact that in the case of a comparatively low NaOH solution concentration the absorbing power of the process was determined by the conditions of the diffusion in the gaseous and liquid phases. It should be noted that the magnitudes of (K) and (η) increased within the concentration range of the solution referred to, despite

the fact that an increase in the NaOH concentration produced a thinner layer of foam under similar conditions as a result of changes in the physical properties of the solutions, such as increased specific gravity, viscosity and surface tension.

Such a course of the curves representing the functional relationship between (K) and the NaOH solution concentration was observed in all the examined rates of gas flow in the apparatus, which ranged between 0.5 and 2 m/sec, closely agreeing with the results published on CO_2 absorption in the packed absorber [13].

The effect of carbonization degree of the NaOH solution on the rate of CO_2 absorption is shown in Fig. 3. Up to 25% carbonization values of (K) and (η) decreased only slightly; at a higher degree of carbonization the values of (K) and (η) sharply decreased. The less favorable conditions accompanying a higher carbonization of the NaOH solution resulted from the decrease in the chemical absorption capacity of the NaOH solution. The above mentioned less favorable conditions are also related to the greater diffusion resistance in the liquid phase caused by the formation of a carbonate layer in the liquid

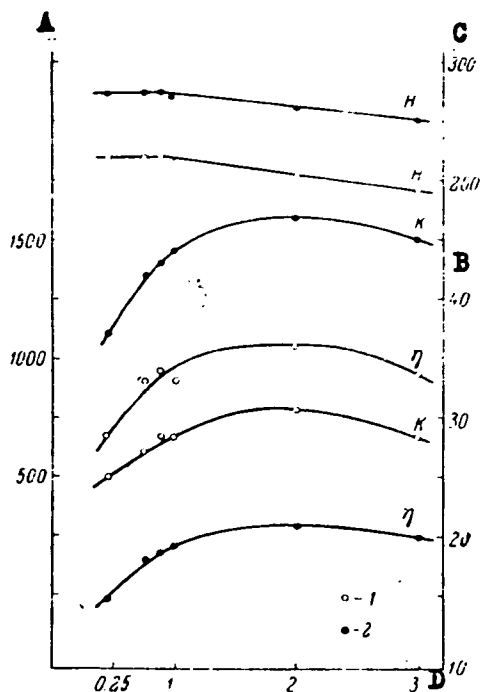


Fig. 2. Effect of NaOH concentration on K , η and H .
 A - K , $\text{m}^2/\text{hr.kg/m}^3$; B - cad or η in %; C - foam crest H in mm; D - sodium hydroxide in gr. equiv. per liter.

Gas flow rate in apparatus in m/sec.:

1 - 0.5, 2 - 2.0.

Screen 5/2. $i = 5 \text{ m}^2 \times \text{hr}$; $h_p = 100 \text{ mm}$

$C_{\text{volx}} = 6\%$; $t = 60^\circ$.

phase; the CO_2 solubility in that layer is considerably less than in the deeper layers of the NaOH solution. This was substantiated by results of experiments on CO_2 absorption by different solutions, all of which contained the same amount of NaOH but different amounts of Na_2CO_3 , as shown in Fig. 4.

After bicarbonization of the soda solution increased from 20 to 25%, the rate of CO_2 absorption began to increase, due to the falling out of the formed bicarbonate which enhanced the carbon dioxide solubility in the system

[4], as can be seen in Fig. 3.

The functional relationship between (K) or (η) and temperature is shown in Fig. 5. With a temperature rise from 20° to about 45 or 50° the CO_2 absorption increased due to the favorable effect of the higher temperature on the rate of chemical reactions paralleled by more favorable conditions for the formation of foam. With further rise in temperature the values of (K) and (η) remained practically constant, and even slightly decreased at 70 to 80° . Accordingly, a range of 50 to 70° is optimal for the process of CO_2 absorption by an alkaline solution.

Fig. 6 shows the effect of liquid flow rate (r) on (K) and (η). The flow rate (r) is expressed in $\text{m}^3/\text{m}^2/\text{hours}$; its magnitude depends upon the size of the outflow opening of the shelf screen of the apparatus. Increase in the values of K and η with the increase in (r) is a functional consequence of the

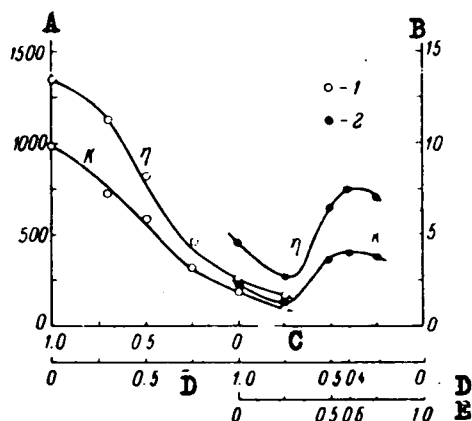


Fig. 3. Effect of solution carbonization on K and η .

A - Absorption coefficient K in $\text{kg/m}^2 \cdot \text{hr} \times \text{kg/m}^3$
 B - Degree of absorption cad or η in percent.
 C - NaOH in solution in g. equivalent per li.
 D - Sodium carbonate in solution in g equiv/li
 E - NaHCO_3 in solution in g equivalent per li
 Initial concentration of carbon dioxide in the gas C_{volx} in volume %: 1 - 6, 2 - 30.
 Screen 5/2. $w = 2.0 \text{ m/sec.}$; $i = 5 \text{ /m}^3/\text{m} \cdot \text{hr}$; $h_{\pi} = 100 \text{ mm}$; $t = 18^\circ$.

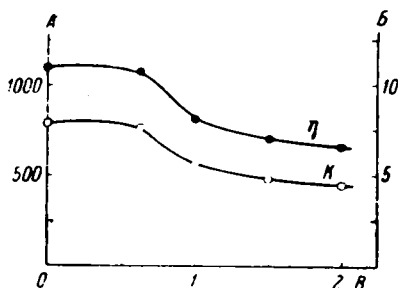


Fig. 4. Effect of sodium carbonate in sodium hydroxide solution on K and η .

A - Absorption coefficient K in $\text{kg/m}^2 \times \text{hr} \cdot \text{kg/m}^3$; B - degree of absorption cad or η in %; C - sodium carbonate content in sodium hydroxide solution in g equiv./li.
 Screen 5/2. $w = 2.0 \text{ m/sec.}$; $H = 220 \text{ mm}$; 3 N NaOH solution; $C_{\text{volx}} = 6\%$; $t = 18^\circ$.

portion to the increase in the height of the foam layer.

The data plotted in Fig. 7 were obtained at constant flow rate (r) with a constant threshold height (h_t) i.e., for a constant height of the initial

increase in the thickness or height (H) of the foam layer which enhance the CO_2 absorption rate.

The functional relationship between (K) or (η) and the linear gas flow velocity is more complex and more important, as shown by an analysis of curves in Fig. 7. An increase in (w) causes the foam layer to rise in height; this, in turn, results in a corresponding increase in (K). However, when the value of (w) exceeds $2.5 - 3 \text{ m/sec}$, the

rate of corresponding rise in the values of (K) becomes retarded, due, perhaps, to the reduced contact time between the two phases which is not compensated for by an increase in the interphase areas, all of which lowers the efficiency coefficient of the process [3]. Within a definite and a sufficiently wide range for (w) in practice, approximately up to 2.5 m/sec , the absorption coefficient increased in pro-

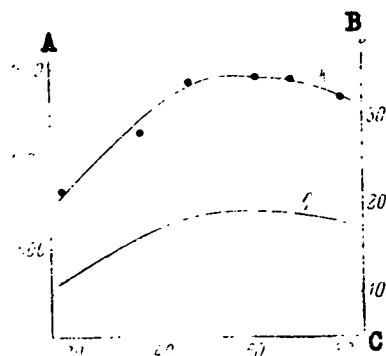


Fig. 5. Effect of temperature on K and η .
A - Coefficient of absorption K in $\text{kg}/\text{m}^2 \cdot \text{hr} \cdot \text{kg}/\text{m}^3$.

B - degree of absorption cad or η in %;
C - temperature in $^{\circ}\text{C}$.

Screen 5/2. $w = 2.0 \text{ m}/\text{sec}$; $l = 5 \text{ m}^3/\text{m} \cdot \text{hr}$
 $h_{\pi} = 100 \text{ mm}$; 1 N NaOH soln. ; $C_{\text{volx}} = 6\%$.

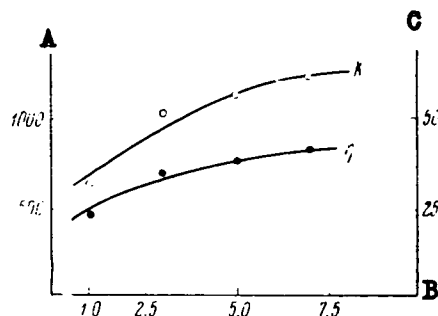


Fig. 6. Effect of liquid flow intensity on K and η .
A - Coefficient of absorption K in $\text{kg}/\text{m}^2 \cdot \text{hr} \times \text{kg}/\text{m}^3$

B - degree of absorption (cad) η in percent.

C - liquid flow intensity i in $\text{m}^3/\text{m} \times \text{hr}$.

Screen 5/2. $w = 0.75 \text{ m}/\text{sec}$; $h_{\pi} = 200 \text{ mm}$. 1 N NaOH
solution; $C_{\text{volx}} = 6\%$; $t = 18^{\circ}$.

liquid layer (h_0) and a variable height of the foam layer. As a matter of theoretical information and to elucidate the physical aspect of the effect of gas flow rate on the different aspects of absorption, it is desirable to establish the (K) and (η) functional relationship to (w) at a constant foam layer height.

Curves in Figs. 8 and 9 represent data obtained for (K) and (η), respectively, in accordance

with the following empirical formulae: $K = f(H)$ and $\eta = \phi(H)$ [1].

The data indicate that with a definite foam layer height the absorption coefficient increased proportionately to the increase of gas velocity in the apparatus, as shown in Fig. 8. To a certain extent it illustrates the true functional relationship between (K) and (w),

since it equally presupposes that other factors, affecting K and depending on the velocity of the gas, would be automatically eliminated if H were constant. It should be borne in mind, however, that conditions at which $H = \text{constant}$ are attainable by changing H_0 , hence, by changing the structure of the gas-liquid system at different (w).

The degree of CO_2 absorption from gas, or the efficiency coefficient of a shelf screen (η) of the apparatus, abruptly drops with the increase in (w),

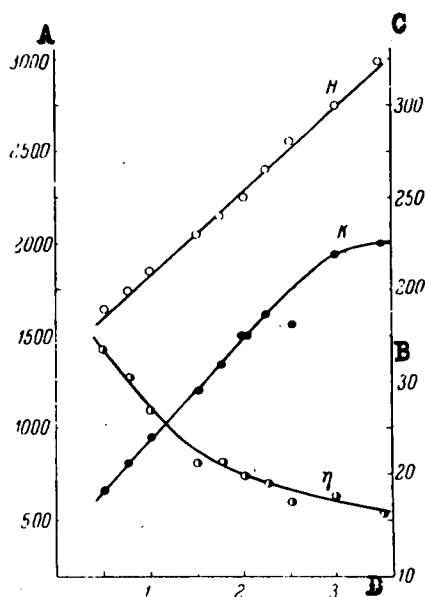


Fig. 7. Effect of gas flow rate through the total apparatus cross-section on K, η and H.

A - Coefficient of absorption K in $\text{kg/m}^2 \cdot \text{hr} \times \text{kg/m}^3$
 B - degree of absorption (cad) η in percent;
 C - foam layer thickness H in mm; D - gas flow rate (w) inside of the apparatus in m/sec.
 Screen 5/2. $i = 5 \text{ m}^3/\text{m} \cdot \text{hr}$; $h = 100 \text{ mm}$; 3 N NaOH solution; $C_{\text{volx}} = 6\%$; $t = 60^\circ$.

as shown in Fig. 9, since with the same foam height and approximately the same phase contact area, the contact time between the gaseous and liquid phases is reduced.

A study of the process of CO_2 absorption by NaOH solution brought out the complexity of the mechanism and the dependence of the process on the state of diffusion in the gaseous and liquid phases, the rates of the chemical reactions, the carbonate ion concentration in the solution and the temperature. The results of the experiments

showed that the intensity of the process as a whole, and consequently, of its constituent stages sharply rose under conditions of highly turbulent foam formation. According to published data [8, 13] CO_2 absorption coefficient by NaOH in a packed absorption apparatus operating under ordinary film conditions, did not exceed 1000 to 1250 $\text{kg/m}^3/\text{hours}/\text{atmospheric pressure}$. At a linear gas velocity through a total cross-section of a foam apparatus equal to 2 to 2.5 m/sec, with a distance between screen shelves of 0.5 m, the absorption coefficient of a foam absorption apparatus is 4 to 5 times greater than of the most generally used packed scrubbers.

Conclusions.

1. The purpose of the study was to determine the completeness and rate of carbon dioxide absorption by a foam layer of sodium hydroxide solution, under different conditions of CO_2 concentration and rate of flow, different NaOH concentrations, degree of carbonization of the alkaline solution and temperature.

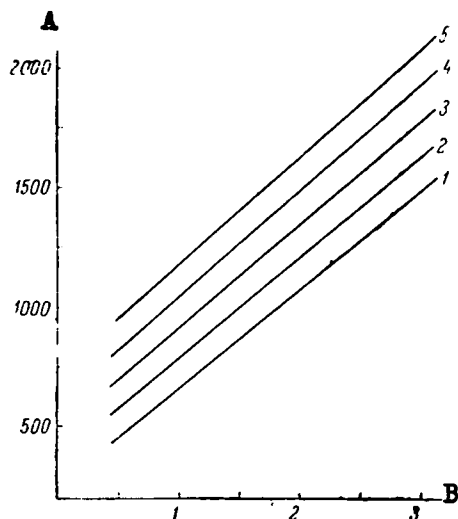


Fig. 8. Effect of gas flow rate through total apparatus cross-section at constant foam layer on the absorption of carbon dioxide.

A - Coefficient of absorption (K) in $\text{kg/m}^2 \times \text{hr. kg/m}^3$;
 B - gas flow rate through the apparatus (w) in m/sec.
 Height of foam layer H in mm: 1 - 100, 2 - 150, 3 - 200, 4 - 250, 5 - 300.

Screen 5/2. 3 N NaOH solution; $C_{\text{volx}} = 6\%$; $t = 60^\circ$.

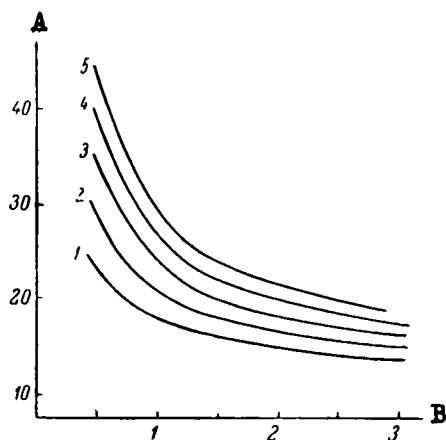


Fig. 9. Effect of gas flow rate through the total apparatus cross-section at constant thickness of foam layer on the rate of CO_2 absorption (cad) η .

A - Degree of absorption (cad) η in %.

B - gas flow rate in apparatus (w) in m/sec.

Foam layer thickness H in mm:

1 - 100, 2 - 150, 3 - 200, 4 - 250, 5 - 300.

Screen 5/2. 3 N NaOH solution; $C_{\text{volx}} = 6\%$; $t = 60^\circ$

2. It was demonstrated that coefficient (K) for carbon dioxide absorption by 3 N NaOH at 60° was practically independent of the CO_2 concentration in the gas within 2 to 15%.

3. The functional relationship between NaOH concentration and coefficient (K) and (η)

reached its maximum at 2 N NaOH.

4. As the carbonization of the sodium hydroxide solution progressed, the magnitudes of (K) and (η) sharply diminished during CO_2 absorption by NaOH solution; these magnitudes were approximately four times as great as during absorption by a fully carbonized NaOH solution. Results of experiments showed that as the rate of carbon dioxide absorption by a sodium hydroxide solution of constant concentration decreased the Na_2CO_3 concentration in the solution increased.

5. The values of the functional relationship between temperature and coef-

ficients (K) and (η) reached their maxima at $45 - 50^\circ$.

6. Within the range of $0.5 - 3.5$ m/sec linear gas flow velocity during absorption of carbon dioxide by 3 N NaOH solution at 60° , the magnitude of (K) increased approximately from 700 to 2000 m/hour, and the magnitude of (η) decreased from approximately 34 to 16%.

7. On the basis of the above data it is possible to choose optimal conditions under which different gases can be freed of carbon dioxide, or for carbonization of alkaline solutions in the foam apparatus.

8. Under properly organized conditions of foam apparatus operation the rate of CO_2 absorption by a solution of NaOH can be increased to 4 - 5 times the rate of the widely used scrubber type gas purifiers.

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Hygienic Aspects of Industrial Vanadium Aerosol.

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Gigiena i Sanitariya, No. 11, 49-53, 1952.

Some reports appeared in Soviet literature which dealt with the problem of sanitary labor conditions in industries producing or using vanadium; some of the reports dealt primarily with the toxicological aspects of vanadium.

This author undertook to examine the conditions and nature of possible effects of vanadium compounds on the organism, to determine the type and properties of vanadium compounds contained in the air, to obtain experimental toxicological data necessary for the hygienic evaluation of industrial plant surroundings, and to arrive at a basis for hygienic measures to be instituted in industrial plants using vanadium.

Vanadium belongs to the group of rare elements. It is rarely found in concentrated spots in the earth's crust, and occurs mainly in the form of oxides and salts in combination with iron, uranium and other metallic ores. As a result vanadium oxides are contained in considerable quantities in blast furnace and open hearth slags. Investigations indicated that during crushing of these slags an aerosol was formed which contained lower oxides of vanadium, oxides of silicon, calcium, iron, and in smaller quantities, titanium, chromium and manganese. Formation of aerosols in the crushing process was caused by insufficient protecting devices, open dust-forming processes and by a lack of on-the-spot ventilation. During slag calcining the air may become polluted by its dust to 50 mg/m^3 concentration. Such dust may contain soluble vanadium salts, sodium vanadate, the air concentration of which can be as high as 5 mg/m^3 .

Vanadium pentoxide is derived from sodium vanadate. Before the pentoxide is used in the production of ferro-vanadium it is melted in smelting furnaces, a process which generates vapor of vanadium pentoxide; such vapor condenses into a vanadium pentoxide aerosol of high dispersion, the particles of which have a diameter of less than 2μ . Data on vanadium pentoxide aerosol distribution in the vicinity of smelters are presented in Table 1. Vanadium pent-

oxide was determined by the method of M. K. Berezova (Gigiena i Sanitariya, No. 7, 1951).

T A B L E 1.

Content of vanadium pentoxide in the air during smelting.

Place of sample taking	Number of samples	Concentration in mg/m ³	
		Maximal	Minimal
0.5 m above the ingot mould during the pouring	8	7.1	16.5
Over the tap hole of the smelting furnace	14	1.9	5.5
Over the charging hole of the smelting furnace	11	4.8	7.2
At working points	14	1.2	1.8
Some distance from working point	12	None found	

Molten vanadium pentoxide is used in production of ferro-vanadium. Prior to its use in the preparation of ferro-vanadium the pentoxide is reduced to its metallic form in electric furnaces. The reduction process is a gradual one: pentoxide \rightarrow tetroxide \rightarrow trioxide \rightarrow oxide \rightarrow metallic vanadium. The question of volatility of the above vanadium compounds while in the electric furnaces is of interest, and importance. Repeated analyses of air over the surface of molten ferro-vanadium indicated that the latter was not the source of vanadium vapor emission into the air. Particles of vanadium compounds were carried off not from the alloy, but from the layer of slag floating over the top of the alloy mass in the electric furnace. Vanadium was present in the slag in the form of calcium vanadate $4\text{CaO} \cdot \text{V}_2\text{O}_5$ (the ferro-vanadium smelting temperature is 2000° , which is the same as the temperature in the vanadium pentoxide electrical reducing furnace) and lower oxides V_2O_4 , V_2O_3 , V_2O_2 and V_2O . According to Polyakov the melting points of vanadium oxides are as follows: V_2O_5 - 658° ; V_2O_4 - 2000° ; V_2O_3 - 1976° and V_2O_2 - 1970° .

The above data show that the lower oxides of vanadium have high melting points; therefore, it can be assumed that their volatility at the electric furnace temperature is insignificant. The melting point of vanadium pentoxide

is low and its vaporization can be expected to be high, as large masses of it momentarily turn into lower oxides; however, it is rapidly reduced to the lower oxides in the electric furnace. On the other hand, under conditions of the electric arc flame, the temperature of which is 3200° , the rate of vanadium vaporization must be considerable. Analysis of the surrounding air made during the melting of ferro-vanadium indicated that dust concentrations in the air can be as high as 67.7 mg/m^3 , and of vapors of lower vanadium oxides as high as 0.45 mg/m^3 . Thus, persons working at ferro-vanadium smelting can be exposed to the effect of aerosols containing highly dispersed pentoxide and lower oxides of vanadium. Those working at crushing and sifting ferro-vanadium may be exposed to the effect of ferro-vanadium dust.

The acute and chronic effects and the hygienic aspects of vanadium compounds were studied experimentally. The chronic tests were made with 20 white rats; animals were placed in the exposure chamber every other day for 2 hours over a period of three months; the chamber air contained $0.003 - 0.005 \text{ mg/li}$ of vanadium pentoxide aerosol which was obtained by burning vanadium pentoxide in an electric arc flame. Fifteen rats of a second series were exposed for one hour daily for a period of 4 months to $0.01 - 0.03 \text{ mg/li}$ of vanadium pentoxide dust of high dispersion. Thus, the vanadium dust entered the animals' respiratory passages by way of natural inhalations. In the third series of tests 15 white rats inhaled highly dispersed dust of crushed ferro-vanadium every other day for one hour; the dust concentration was $1 - 2 \text{ mg/li}$, and exposure extended over a period of two months.

During the first and second months of exposure the weight and behavior of the test animals were practically identical with those of the control animals. During the third month of exposure the gain in weight of the test animals showed a retardation; toward the end of the exposures the test animals began to lose weight simultaneously with the appearance of a bloody nasal mucous discharge.

The general health conditions and behavior of the animals exposed to vanadium dust inhalation appeared to be no different from those of the control animals. Macroscopic post-mortem examinations of the test animals showed no signs of pathology other than hyperemia of the lungs.

Microscopic examination showed the following:

1. Plethora and capillarostasis in the pulmonary tissue, particularly in peribronchial regions, development of perivascular edemas and lymphostases.

Exposure to highly dispersed vanadium pentoxide aerosol produced hemorrhages and focal pulmonary edemas pointing to the graver and more acutely expressed toxic effect of this type of vanadium aerosol.

2. A manifest reaction of interstitial (connective) tissue of the lungs. The character of the reaction was different in the different test series: in some cases of ferro-vanadium aerosol intoxication this reaction resulted in the development of chronic peribronchitis and perialveolitis characteristic of chronic productive pneumonia. In animals exposed to the inhalation of coarsely dispersed vanadium pentoxide, the intermediate productive pneumonia was either weakly expressed or totally absent. In chronic intoxication, caused by highly dispersed vanadium aerosol, there were signs of disturbances in the blood and lymph circulations, in the permeability of the pulmonary blood vessels, also signs of serous desquamative panbronchitis. Sclerotic foci were observed in the region of peribronchial infiltrates. The chronic tests did not extend over a sufficiently long period to permit observation of gross sclerosis development. However, such pulmonary changes as the formation of small sclerotic foci near the bronchi, pointed to the development of gross sclerosis.

The results of chronic tests indicated that the highly dispersed vanadium pentoxide aerosol possessing a high physico-chemical activity, produced grosser pulmonary changes following its inhalation in concentrations considerably below those of a coarsely dispersed aerosol.

Ferro-vanadium dust produced grave pathological changes only at high concentrations indicating that its toxicity was lower than that of vanadium pentoxide. This may have been due partly to the low solubility of vanadium as an alloy constituent in media, the hydrogen concentration of which approximated the biological level; compared with the above, the solubility of vanadium pentoxide in biological media was several times ten as high.

Effects of acute toxicity of vanadium compounds were investigated by experimental procedures much similar to the one previously described. Ferro-vanadium aerosol produced no acute intoxication of animals even with 10 mg/li concentrations, perhaps as a consequence of slow transition of vanadium from the alloy into the biological medium.

Aerosol of crushed vanadium pentoxide produced acute intoxication of animals exposed for one hour to concentrations of 0.08 mg/li and higher. Concentrations of 0.7 - 0.8 mg/li were absolutely lethal to the test animals. 1 -

1.3 mg/li concentrations of ammonium vanadate were also absolutely lethal.

Animals were exposed to the vanadium pentoxide condensate for two hours. The minimum concentration which caused acute intoxication was 0.01 mg/li; absolute lethal effect was produced by 0.07 mg/li.

The clinical picture of acute intoxication with the vanadium compounds was as follows: passive behavior of the animals and loss of weight; animals exposed to high aerosol concentrations suffered paralysis of the hind extremities, and diarrhea, which brought about death 20 - 80 hours after exposure.

In cases of acute intoxication vasodilatation and blood stasis were observed in all the internal organs; intoxication brought about cerebral fluid stasis.

Thus, the most characteristic manifestation of vanadium toxicity was disturbance of the circulatory system; vasodilatation and blood stasis in the vessels of internal organs. These changes assume a regional character: they were observed only in the lungs and apparently, lead to a disturbance in vascular permeability; pulmonary lymphostasis accompanied by a lowered drainage function which enhanced the development of the pulmonary pathological processes. In acute intoxication the disturbance in the circulatory system embraced the most important regions of the organism, such as the organs in the thoraco-abdominal cavity and the cerebrum. Nerve tissue is particularly sensitive to lack of blood supply, and particularly so in stasis of the cerebral fluid. Therefore, circulatory disturbances lead to disturbances in the brain function, which, in turn, aggravated the primary circulatory disturbance. These phenomena were observed in vanadium aerosol intoxication caused by exposure to high concentrations of vanadium pentoxide and ammonium vanadate in the air.

For attainment of rational prophylaxis against occupational intoxication with vanadium and other industrial dusts, it is necessary to reduce their concentrations in the air of the working premises. This can be achieved by diverting the dust into ventilating ducts installed strategically at points where the dust was generated. The concentration of vanadium pentoxide in the air can be substantially lowered by improving the process of vanadium pentoxide smelting in the direction of lowered vanadium pentoxide volatility. Vanadium pentoxide should not be charged directly into the region of the electric arc of the smelting furnace, but first into the molten mass where it will melt

and become reduced to the refractory lower oxides; such a loading procedure will sharply lower the volatility of vanadium pentoxide.

In attempting to determine the limits of allowable concentrations of aerosol of vanadium compounds in the air, consideration should be given not only to the chemical composition of the aerosol particles, but to their physico-chemical properties as well. In this respect the degree of particulate dispersion is of primary consideration. In the case of ferro-vanadium the bond between vanadium and iron renders it less toxic, than ammonium vanadate; accordingly the limit of allowable concentration of the former can be set at a higher level than of the latter; on the other hand, the limit of allowable concentration of vanadium pentoxide should be set at a level lower than that of ammonium vanadate; likewise the limit of allowable concentration of vanadium pentoxide in the aerosol form must be set at a level lower than the concentration of vanadium pentoxide in the form of a coarsely dispersed dust.

On the basis of the results of this investigation it is recommended that the following limits of allowable concentrations of dust or aerosol of vanadium compounds in the air of working industrial premises be adopted on a provisional basis:

For vanadium pentoxide in the form of aerosol condensate - 0.0001 mg/li; for crushed highly dispersed vanadium pentoxide - 0.0005 mg/li; for highly dispersed dust of soluble vanadium salts - 0.0005 mg/li; for ferro-vanadium dust - 0.001 mg/li.

The study of the toxicity of dust and aerosols of vanadium compounds should be continued on a broader and more precise basis and the above recommended provisional limits should be revised, amended or replaced in accordance with the results of latest studies.

Effect of Vitamins C, PP, and B₂ on the Course of Acute Poisoning by
Orthonitrochlorobenzene.

By

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Treatment of poisoning by methemoglobin-forming substances is now a pressing problem due to the large-scale use by the chemical industry of compounds capable of penetrating into the human organism and producing methemoglobin. Hypoxia develops after a substantial amount of methemoglobin forms in the blood.

Studies of A. I. Cherkes, Ye. A. Vladimirova, E. E. Martinson, V. M. Potapova and A. P. Urinson have demonstrated that methemoglobinemia caused by nitrochlorobenzene or sodium nitrite disturbed the processes of metabolism, in particular carbohydrate metabolism, as manifested by the appearance of hyperglycemia and hyperlactacidemia. The ability of the organism to oxidize fatty acids is somewhat weakened, and there is a drop in the carbonic acid content of the blood. In most instances the blood pH rises and hyperketonemia develops. The extent of changes in metabolism and the outcome of the poisoning depend, within certain limits, directly on the amount of methemoglobin present. According to literature, concentrations exceeding 60 to 65% are to be regarded as lethal. This has been confirmed by Yu. S. Grosman and E. A. Legeda in their studies on vitamin therapy in acute sodium nitrite poisoning. In treating conditions caused by methemoglobin-forming poisons the conversion of methemoglobin into hemoglobin must be enhanced to the possible maximum. Such a process takes place as well in the absence of specific treatment on the 2nd or 3rd day, as was shown by Dittrich and Aron in their tests with dogs; but the process was slow and gradual.

W. A. Englehardt, Warburg, Wendel, V. S. Shapot, E. A. Vladimirova, B. G. Gordon, E. E. Martinson and V. M. Potapova, I. F. Seits, T. I. Ivanova and others established that methemoglobin reduction was a complex, still incompletely investigated, enzyme process in which the dehydrogenase systems were the chief participants. In the opinion of these authors, stimulation of these enzyme systems should affect favorably the rate of methemoglobin reduction

and the general course of intoxication. It is generally known that several vitamins in the B complex group also belong to the active dehydrogenase groups; therefore, it was decided to determine the presence of some of them in methemoglobinemia. In this respect the most promising was a combination of nicotinic acid and ribloflavin in the presence of ascorbic acid; according to I. F. Seits the latter acted as an intermediary in carbohydrate reduction between the individual enzyme links in the process. Such a vitamin combination was used successfully in treating acute sodium nitrite poisoning in rabbits (Yu. S. Grosman and E. A. Legeda); the effectiveness of such treatment was greater than that of methylene blue. Therefore, it was decided to experimentally apply such treatment to several cases of grave poisoning using animals which readily formed methemoglobin and which eliminated it with greater difficulty than did rabbits.

The procedure. The experiments were performed on 35 cats in comparable series, employing as far as possible animals of the same sex and weight. Chemically pure orthonitrochlorobenzene in doses of 100 mg/kg in 0.5 ml of acetone was injected subcutaneously in the abdominal region. According to V. F. Mel'nikova such a dose was lethal for cats. 40 mg/kg of ascorbic acid combined with 5 mg/kg of sodium nicotinate and 0.4 mg/kg of ribloflavin were injected subcutaneously or intravenously 30 minutes after the injection of the orthonitrochlorobenzene.

Body temperature was taken rectally in the control and experimental animals. Blood methemoglobin was determined by Lavrovskii's method, blood sugar by the method of Hagedorn and Jensen, and alkali reserve by the Van Slyke method. Blood for analysis was drawn from the femoral vein before poisoning and 2, 4, 6 and in some experiments 24 hours after poisoning. In experiments with rats studies were made of changes in activity of muscle succinic dehydrogenase following the injection of 150 mg/kg of orthonitrochlorobenzene and of the effect of the vitamin combination on dehydrogenase activity.

A succinic dehydrogenase preparation was made from muscles of decapitated animals according to Szent-Gyorgy's method (muscle paste washed twice with distilled water). The paste was prepared in the cold by grinding 4 g of thigh muscle, free from connective tissue, with the aid of 2 g of glass powder. 300 mg portions of the paste were placed into Thunberg test tubes followed by 0.8 ml of a buffer solution made up of 0.7 ml of m/5 K_2HPO_4 + 0.1 ml of m/5

KH_2PO_4 . 0.1 ml of 1:500 methylene blue and 0.1 m/5 of sodium were introduced according to Chepinoga's method; the control tubes received corresponding amounts of distilled water. Each experiment consisted of 5 Thunberg tubes in the case of the test animals and 3 for the controls. After exhausting as much of the air as possible, the tubes were quickly but carefully shaken and placed into an incubator at $38^\circ \pm 2^\circ$. Observation was continued until the methylene blue became completely decolorized.

Four series of experiments were performed using 40 rats, 10 in each series. The first series was designed for the determination of normal dehydrogenase activity; the second for the determination of dehydrogenase activity 3 hours after subcutaneous injection of a combination of vitamins C, PP and B_2 in the above-mentioned doses; the third for the determination of dehydrogenase activity 3 hours after poisoning by orthonitrochlorobenzene; the fourth for the determination of dehydrogenase activity 3 hours after poisoning by orthonitrochlorobenzene, followed 30 minutes later by the injection of vitamins C, PP, and B_2 combined in above mentioned doses.

Experiments with cats.

First series (control). Experiments were performed with cats weighing 2.1 to 3.7 kg. Poisoning developed comparatively slowly after subcutaneous injection of nitrochlorobenzene. Three to four hours later there appeared dyspnea, cyanosis of the mucosa of the eyes accompanied by a grayish-brown color characteristic of methemoglobinemia. Six hours after poisoning the body temperature dropped by an average of 5° (from 37.8° to 32.9°). Marked hyperglycemia averaging 255 mg % developed in all the animals (Fig. 1) with a maximum 4 hours after poisoning; the control standard amounted to 140 mg %. After 6 hours the hyperglycemia dropped to an average of 234 mg %, and after 24 hours the blood sugar level returned to normal in the surviving animals. The alkali reserve after poisoning decreased (Fig. 2); after 6 hours it fell to an average of 32% below the original. There was a definite shift toward acidosis in the control animals. During the first 6 hours after poisoning methemoglobin was found in the blood of 8 of the 10 cats (Table 1).

Table 1 shows wide variations in the controls with respect to time of methemoglobin appearance and its concentration in the blood. Within 6 hours after poisoning the methemoglobin ranged between 47 and 74%. One cat survived and 9 animals died during the first few days. The 100 mg/kg dose of ortho-

T A B L E 1.

Percent of methemoglobin in the blood of control animals
injected with orthonitrochlorobenzene.

Test No.	Standard	Methemoglobin after -				Survival
		2 hours	4 hours	6 hours	24 hours	
1	0	0	0	0	Not determined	Less than 24 hours
2	0	0	Trace	51%	Not determined	Less than 24 hours
3	0	50%				+ after 2 hours
4	0	0	0	48%	Not determined	Less than 24 hours
5	0	0	31%	47%	Not determined	Less than 24 hours
6	0	68%				+ after 4 hours
17	0	0	0	0	Not determined	Less than 24 hours
18	0	0	0	Trace	Not determined	Survived
27	0	0	Trace	69%	Not determined	Less than 24 hours
31	0	Trace	53%	74%	Not determined	Less than 24 hours

nitrochlorobenzene used came very close to being lethal.

Second series (subcutaneous injection of a combination of vitamins C, PP, and B₂). Experiments with subcutaneous injection of the vitamins 30 minutes after poisoning were performed with cats weighing 1.7 to 3.8 kg. The general course of poisoning in this group of animals was lighter than in the controls; dyspnea and cyanosis of the mucous membranes were less pronounced. The temperature of the treated animals 6 hours after the beginning of intoxication averaged 0.7° above the controls. The blood sugar level 2 hours after poisoning was about the same as in the control experiments, but the slope of its curve was steeper; after 4 hours the blood sugar level of the treated animals averaged 54 mg %, and after 6 hours 28% less than in the controls (Fig. 1). Judged by the relative percent rise in the blood sugar level, the glycemic

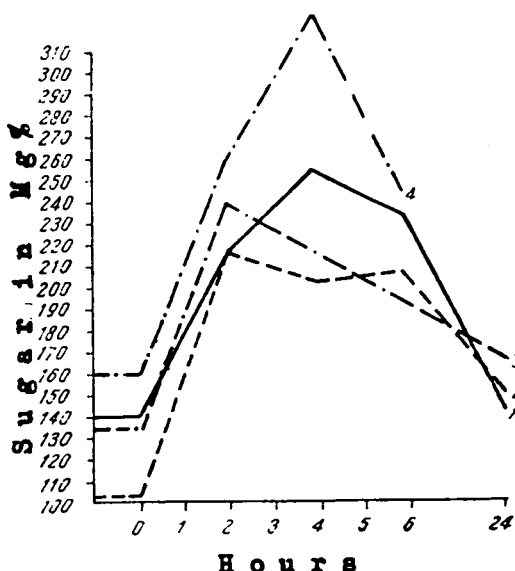


Fig. 1. Effect of orthonitrochlorobenzene on the blood sugar level
 1 - Control, untreated animals; 2 - subcutaneous injection of combination of ascorbic acid, Na-nicotinate and riboflavin 30 min. after poisoning; 3 - intravenous injection of same vitamin combination 30 min. after poisoning; 4 - intravenous injection of 5 mg/kg of methylene blue

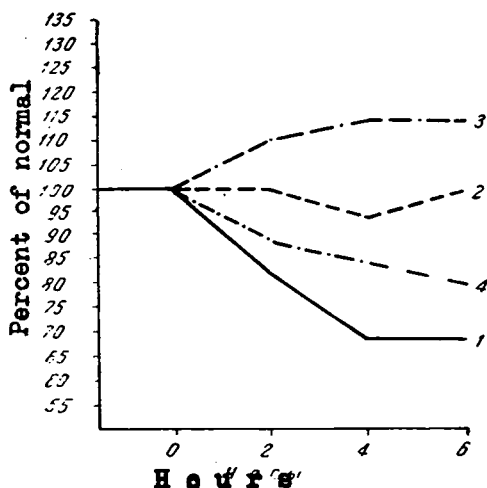


Fig. No. 2. Effect of orthonitrochlorobenzene on alkaline reserve

Curves 1, 2, 3 and 4 same as in Fig. 1.

curves of the treated and control animals were approximately identical. Fig. 2 shows that 6 hours after poisoning the alkali reserve in this group of animals remained within its normal limits. Thus, the subcutaneous injection of vitamins C, PP, and B₂ prevented the appearance of acidosis which normally developed in this type of poisoning.

No methemoglobin was found in 7 of 10 experimental animals during the first 6 hours. 36 to 39% methemoglobin was noted in 2 after 6 hours; after 4 hours it amounted to 40% and after 6 hours to 60% in one test animal. It was clear, then, that the subcutaneous injection of the vitamin combination prevented, or effectively arrested, the development of methemoglobin in animals poisoned by orthonitrochlorobenzene. In the series under discussion 5 animals survived, and 5 died.

Third series (intravenous injection of a combination of vitamins C, PP and B₂). Simultaneous intravenous injection of vitamins C, PP and B₂ 30 minutes after poisoning by orthonitrochlorobenzene alleviated even more emphatically the course of intoxication. Of 10 cats weighing 1.8 to 3.3 kg, 7 survived and 3 died. No mucous

membrane coloring typical of methemoglobinemia was noted in any of the animals throughout the experiments. Six hours after poisoning the temperature of the experimental cats was on an average 2.2° higher than of the controls. The sugar curve in the treated animals rose 23% within the first 2 hours after poisoning as compared with the controls; later it fell to a level considerably below the controls (30 to 40 mg %) (Fig. 1). Fig. 2 shows that the alkali reserve of the animals in this group remained 10 to 14% higher than the original level throughout the entire period of observation. No methemoglobin was found in 8 cats during 6 hours of observation. Experiment No. 29 of this series, where the cat died after 2 hours (probably due to the nitrochlorbenzene solution accidentally getting into a blood vessel) showed a methemoglobin concentration of 52%. The methemoglobin concentration in a second cat amounted to 50% six hours after the injection of the poison. It was obvious that here, too, the intravenous injection of the combination of vitamins C, PP and B₂ clearly arrested the development of methemoglobinemia in most test animals and resulted in the survival of more animals than following subcutaneous injection.

Check experiments with methylene blue. The experiments were performed with 5 cats weighing 2.1 to 2.8 kg. Methylene blue was injected intravenously 30 minutes after poisoning by orthonitrochlorobenzene, in 5 mg/kg doses. An 0.5% solution of methylene blue in an isotonic salt solution was used. Of 5 animals 3 died and 2 survived. During 6 hours of observation traces of methemoglobin were noted in only 1 cat. This indicated that in the case of acute orthonitrochlorobenzene poisoning prevention of methemoglobinemia alone is no index of survival. The developed hypoxia follows a complex, still inadequately defined pathogenic course. Despite the absence of methemoglobinemia, the sugar curves in the test animals were considerably higher than in the controls (Fig. 1). The alkali reserve decreased, and 6 hours after poisoning was on the average 19% below the original level (Fig. 2).

Hence, unlike the vitamin combination, methylene blue did not prevent acidosis from appearing after orthonitrochlorobenzene poisoning. The dye lightened the course of poisoning as compared with the control. Six hours after poisoning the body temperature of the animals dropped an average of 4.6° , the same as in the control experiments.

Experiments on rats.

Results of experiments made to determine changes in succinic dehydrogenase activity after acute orthonitrochlorobenzene poisoning in rats and the effect of treatment with the combination of vitamins C, PP and B₂ are presented in Table 2. The data show that 3 hours after poisoning the animals' succinic dehydrogenase activity was considerably inhibited, as was indicated by an increase in the time required for the complete decolorization of methylene blue from an average of 16 minutes in the controls to 27 minutes in the poisoned animals. The vitamin C, PP and B₂ combination which in intact rats barely affected succin dehydrogenase activity, in orthonitrochlorobenzene poisoning considerably enhanced its return to normal. The data support the assumption that the higher survival rate of orthonitrochlorobenzene poisoned animals treated with the vitamins C, PP and B₂ combination depended not only on partial or total elimination of methemoglobinemia, but also on normalizing the functioning of the oxidation-reduction enzyme system, and particularly of dehydrogenase.

T A B L E 2.

Test series	Number of determinations		Average methylene blue reduction time	
	Test	Control	Test	Control
First	50	30	11 min	No reduction
Second	50	30	14 min	No reduction
Third	50	30	27 min	No reduction
Fourth	50	30	18 min	No reduction

Conclusions.

1. The injection of ascorbic acid together with sodium nicotinate (5 mg/kg) and ribloflavin (0.4 mg/kg) 30 minutes after poisoning cats with orthonitrochlorobenzene (100 mg/kg subcutaneously) favorably affected the course of poisoning. This was indicated by the higher survival rate of treated animals as compared with the untreated controls, by the considerable inhibition in the development of methemoglobinemia, by the disappearance of acidosis symptoms, by the normalization of dehydrogenase activity (in experiments with rats), and by a less pronounced hypothermia.

2. Intravenous injection of the vitamins was more effective than subcutaneous injection.

3. Methylene blue injected in dose of 5 mg/kg under the same experimental conditions prevented the development of methemoglobinemia; in all other respects it was inferior to the tested vitamin combination.

4. The results justify recommending that the C, PP and B₂ vitamin combination be given a clinical trial in the treatment of cases poisoned by methemoglobin-forming substances.

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The Peculiar Relationship between Air Concentrations of Some Volatile Substances and the Development of Pulmonary Edema.

By

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Certain unsaturated highly reactive chemical compounds are used in the production of synthetically polymerized materials. In this connection the complex esters of vinyl alcohol with saturated fatty acids, such as vinyl acetate, vinyl propionate and vinyl butyrate are of immediate interest. A study of the toxic properties of vinyl propionate and of vinyl butyrate in-

licated that the inhalation of the vapors of these esters by white mice produced narcotic effects and developed pulmonary edema. Preliminary observations indicated that different concentrations of the ester vapor elicited pathologic manifestations of different intensity. This was verified by a series of experiments.

A. N. Charnyi in 1935 and Poulsen in 1954 based their determinations of quantitative pulmonary changes in edemas on the degree of fluid accumulation in the lungs. Jaffe (in 1934) determined the ratio of weight of the edematous lungs to the weight of the same lungs after drying to constant weight. The simplest and most commonly used method is the one known as the "pulmonary coefficient" determination, the results of which are expressed as the ratio of weight of the lungs to the weight of the animal's body. According to Flury and Tsernik (1938) the pulmonary coefficient of normal mice varied within the limits of 6.5 and 11.5. This author found that in 20 mice weighing 17 to 21 g the pulmonary coefficient varied within the limits of 7.2 and 9.4.

Inhalation exposure tests were made in series of groups of 10 mice as follows: control groups, and groups exposed to the inhalation of 2, 4, 6, 8, 10, 16, 32 and 48 mg/li of the ester vapors. The total of mice used including the controls was 180. Exposures were made by the static method by placing the mice into glass jars. Concentrations of the vinyl esters in the jars were attained by the usual method; animals were exposed to the ester concentration for 2 hours.

Lungs were removed from the body by first ligating the trachea to prevent any leakage from the lungs; the organs were weighed on torsion scales with a 1 g accuracy. Blocks in Fig. 1 are plots of pulmonary coefficients of the controls and of the mice exposed to the different concentrations of vinyl propionate. Pulmonary coefficients were plotted along the ordinate and the ester vapor concentrations were plotted along the abscissa; numerical values inscribed within the blocks represent pulmonary coefficient averages for each group of 10 animals; indentation steps within each block represent the pulmonary coefficients of individual animals.

The blocks in Fig. 1 clearly illustrate the fact that increase in ester concentration was followed by an increase in the pulmonary coefficient up to a point of maximum, which was 8 mg/li in the case under consideration. Any increase in the vinyl ester vapor concentration beyond the maximal point, was accompanied by a notable lowering in the pulmonary coefficient, pointing to

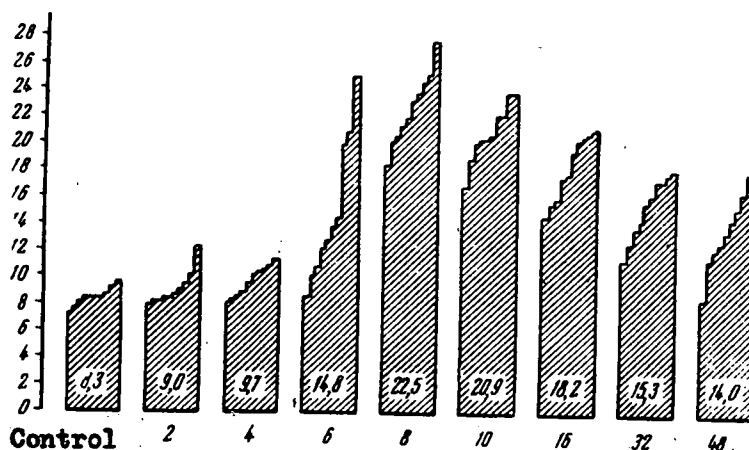


Fig. 1. Effect of vinyl propionate vapor concentration on the pulmonary coefficient of white mice.

the fact that vinyl propionate vapor concentrations above the indicated maximum were less toxic to the mice. It can be assumed that 10 mg/li of vinyl propionate vapor induced in the mice a state of narcosis not effected by lower concentrations of the ester. (Note: At this point editors of the Journal pointed out that the author formed his assumption without taking into consideration such important facts as duration of edema development, time of test animal's death at different vapor concentrations, etc. B.S.L.).

Tests with vapor of vinyl butyrate were conducted following the previously described procedure. In this case, the narcotic state was elicited in the test mice at 48 mg/li vapor concentration. At this vapor concentration the pulmonary edema of the test animals was not as pronounced as in the animals exposed to the 32 mg/li concentration of the vinyl butyrate vapor. The values of the pulmonary coefficients were: 8.5 at 2 mg/li; 11.5 at 4 mg/li; 11.9 at 6 mg/li; 12.8 at 8 mg/li; 20.3 at 10 mg/li; 20.6 at 16 mg/li; 20.0 at 32 mg/li, and 16.9 at 48 mg/li. Thus, the results of tests with the vapor of vinyl butyrate followed a course similar to that of vinyl propionate; this adds some weight to the assumption that the narcotic effect of the vinyl esters at certain concentrations lowered their pulmonary edema producing power.

This assumption was checked as follows: 10 test mice were deeply narcotized by subcutaneous injection of 0.32 ml of 0.5% solution of Na-amytal and then exposed to 8 mg/li concentration of vinyl propionate, a concentration of the ester which elicited most pronounced pulmonary edema in the preceding experimental exposure; for control purposes 10 non-narcotized animals were exposed to the

same concentration of the vinyl propionate. At the end of 2 hours exposure 8 of the 10 control non-narcotized animals died; all the 10 narcotized mice survived. The surviving animals were sacrificed and their pulmonary coefficients determined. The values obtained were plotted by the block method, as illustrated in Fig. 2, the legend of which is self-explanatory. The block plots clearly indicate that the intensity of pulmonary edemas in the narcotized mice at all concentrations of the vinyl ester vapor was about 50% of the intensity in the non-narcotized mice; the average pulmonary coefficient of narcotized mice was 10.9 and of the non-narcotized mice 19.5.

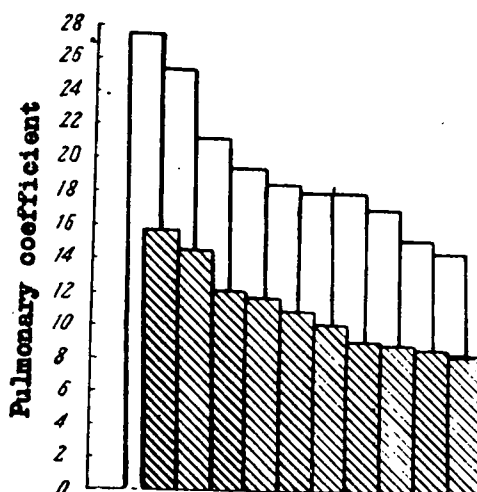


Fig. 2. Pulmonary coefficients in mice poisoned by vinyl propionate vapor: white blocks - preliminary Na-amytal narcotization followed by exposure to identical vinyl propionate concentrations.

The previously expressed assumption was further checked as follows: 10 mice were exposed to 32 mg/li concentration of vinyl propionate for 5 minutes, as a result of which the animals became deeply narcotized. Then the 10 narcotized mice and 10 control non-narcotized mice were exposed for 2 hours to 8 mg/li concentration of vinyl propionate.

Most of the vinyl propionate narcotized mice failed to come out of the narcotic state. All the exposed mice died within the 2 hour exposure. Pulmonary coefficient determinations made on all mice are listed in the following Table. Under special conditions of the experiment all the test mice inhaled prearranged higher concentrations of the vinyl ester vapor than the control mice, even in such cases the pulmonary coefficients of the test mice were of lower values than of the controls. The most plausible explanation of such effects lies in the fact that the test mice were in a state of narcosis at the time the pulmonary edema was developing. It should also be pointed out that the test mice survived longer than the control mice. The series of experiments followed similar if not parallel courses and support the assumption

Test mice		Control mice	
Lung coefficient	Death in minutes	Lung coefficient	Death in minutes
24.4	69	34.6	55
22.8	48	22.2	40
20.9	48	21.3	32
21.8	46	20.2	30
19.3	45	20.2	27
18.8	43	20.0	26
18.4	41	19.3	22
18.2	39	18.8	17
17.7	35	18.2	14
14.7	22	16.7	13
<u>Averages</u>			
19.7	43.6	21.2	27.6

that the narcotic state of the mice lowered the intensity of the toxic edema of the lungs in the mice. In 1955 V. D. Bartener working with vinyl acetate obtained results identical with those presented by this author.

Numerous investigations, especially those of recent years, emphasized the important role played by the nervous system in the pathogenesis of pulmonary edemas. Suisada (1928) prevented the development of adrenalin-produced pulmonary edemas by the injection of morphine, chlorethane, chloral hydrate, and other substances, which had an inhibiting effect on the nervous system. According to Poulsen (1954) preliminary narcotization of mice with ether and alcohol considerably slowed up the development of pulmonary edemas caused by the inhalation of carbon dioxide. Tennecoon (1954) used a variety of substances which depressed the central nervous system to prevent the occurrence of pulmonary edemas elicited by intraperitoneal injection of thiosemicarbazide. It is possible to prevent the development of pulmonary edemas in mice elicited by ammonium chloride by the intraperitoneal injection of novocain, as was shown by Goetzegen and others in 1954. Similarly convincing evidence was presented by I. A. Serebrovskaya (1952, 1955) who was engaged in pharmacological studies of the effect of exclusion of different sections of the nervous system on the development of pulmonary edemas in rats and in guinea pigs. S. M. Laites and N. P. Smirnov (1956) and many other investigators presented experimental evidence of the participation of the nervous system in the pathogenesis of pulmonary edema. G. S. Kan (1953) published a special monograph on the subject of

the effect of the state of the nervous system on pulmonary edema development; he analyzed a number of reports appearing in the literature and concluded that the nervous system played a leading role in the pathogenesis of pulmonary edema. In view of the above it appears reasonable to assume that the extent of development of pulmonary edemas by vinyl acetate, vinyl propionate and vinyl butyrate also depended on the state of the animal's nervous system.

A peculiar characteristic of the toxicity of vinyl esters and the interesting theoretical aspects it presents are found in their simultaneous effects as narcotics and as inciters of pulmonary edemas which produce a type of "toxicological paradox", namely, that the higher concentrations of the vinyl esters are less toxic than their lower concentrations.

Conclusions.

1. Exposure of mice to the inhalation of vapors of vinyl propionate and of vinyl butyrate elicited toxic pulmonary edemas and a state of narcosis.

2. The development of pulmonary edemas by vinyl propionate and vinyl butyrate vapors is enhanced by an increase in the concentration of the esters only up to corresponding maxima; concentrations of the ester vapor above such maxima induce in the exposed animals a state of narcosis and produce a less marked pulmonary edema. This phenomenon has been widely observed by other investigators who studied the effect of the state of the nervous system on the development of pulmonary edemas.

3. In the case of vinyl esters the point of peculiar interest is the fact that the toxic and narcotic effects are properties of the same substance.

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Acute Dichlorethane Poisoning.

By

G. N. Morozov.

Farmakol. i Toksikol., Vol. 2, No. 1, 76-78, 1958.

In view of the comparative infrequency of dichlorethane poisoning, two such cases which were recently observed are worth describing. One patient recovered, the other died.

On August 19, 1955, an ambulance brought to the hospital S. and D., both 20 years old, 4 hours after they had swallowed some unknown liquid. Their condition was moderately serious. They stated that 30 minutes after swallowing the substance they felt dizzy and nauseous, and vomited. They did not call for medical help until 3 hours later, when their condition was noticed by neighbors.

Upon admission, D. was somewhat faint, sleepy and nauseous. He continued to vomit bile and gastric content. His face and extremities were cyanotic and the conjunctival vessels were plethoric. An alcohol-like odor emanated from his mouth. Heart sounds were dull, with moderate tachycardia of 92 contractions per minute; arterial pressure was 115/75 and respiratory excursions 20 per minute; temperature was 37.5°.

On the morning of August 20, 1955, 17 hours after admission, his condition worsened despite treatment. He complained of a severe headache, pain in the substernal region, loose stools, without mucus or blood, several times during the night. Nausea and periodic vomiting continued. No urine was passed during the night; in the morning 120 ml of turbid reddish urine was obtained by means of a catheter (see analyses). The patient was apathetic and unwilling to answer questions. Skin of face was hyperemic, and cyanotic and scleral vessels were congested. Pulse was weak, rhythmic, 120 beats per minute. Arterial pressure dropped to 95/55. Heart of normal size, beats thudding and clear with some scattered, dry rales. Tongue coated white. Tenderness in the subcostal region upon palpation. Liver defined along edge of costal arch, edge soft. Spleen not palpable. Pasternatski symptom weakly positive on the right side. Pain upon movement of eyeballs. Bilateral Marinesco-Radovichi symptom. Decrease in tendon reflexes but no aniso reflexes. Slight stiffness of the neck and pain in the spine upon bending head forward. Suggestion of Kernig's symptom on both sides.

The condition became serious August 21. Same complaints continued. Edema of the eyelids. Arterial pressure 105/60. Increase in scattered, dry rales. Number of respiratory excursions 22 a minute. Rejected food as on the days before. Periodic vomiting of gastric juice mixed with bile and copious loose stools without mucus or blood. Elimination of 250 ml of turbid reddish urine during 24 hours.

August 22, the condition was deteriorating. Pains in the right subcostal region became more intense, eyelids edematous, face hyperemic. Hemorrhage under the conjunctiva near the outside corner of the left eye, but fundus normal. Vomiting became less frequent, 2 to 3 loose stools a day with admixtures. Patient still very apathetic, answered questions reluctantly. Pulse weak, rhythmic, 112 beats a minute. Arterial pressure 115/60. Heart margins normal, first sound strong at apex, systolic murmur heard there. Scattered, dry rales. Tongue coated white, dry. Abdomen distended and tense, highly sensitive in epigastral and right subcostal regions.

By percussion, liver edges were determined as being 2 cm below the costal arch. Spleen not enlarged. In applying a paraneural novocaine block according to the Vishnevskii in connection with oliguria and intestinal paresis, hemorrhages were noted in the adrenal gland to the left. On the same day there was heavy nose bleeding and copious vomiting of "coffee grounds". Towards the evening hemorrhages under the conjunctiva of the left eye spread over the entire surface of the sclera. Petechial hemorrhages in the area of the thigh skin. The pinch symptom was pronounced. Pain on moving eyeballs. Tendon reflexes heightened, nothing pathological. Moderate rigidity of occipital muscles and pain on bending head. Kernig's symptom weak on both sides. Oliguria set in (August 22 only 20 ml of urine obtained with catheter). Temperature throughout the illness did not rise above 38°.

On the morning of August 23 the condition of the patient became grave. He lost consciousness. Respiration loud, gurgling. Skin of face and extremities cyanotic. Frothy fluid from mouth. Pulse weak, rhythmic, 122 beats per minute. Arterial pressure 95/20. Heart sounds dull. Number of respiratory movements 28 to 32 a minute. Medium and coarse moist crepitant rales. Reaction of pupil to light very weak. Despite treatment, the patient died 3 hours after losing consciousness with symptoms of heart failure and pulmonary emphysema.

Clinical diagnosis: acute poisoning by an unknown liquid. ¹

Toxic nephrosis with acute oliguria. Toxic hepatitis. Hemorrhagic syndrome (nasal, gastric subconjunctival, and intradermal bleeding). Toxic myocarditis with symptoms of decreased vascular tonus. Symptoms of toxic meningitis. Pulmonary emphysema.

Pathonatomical diagnosis: dichlorethane poisoning.

There was a necrosis of the mucous membrane of the stomach and intestines; edema of the stomach walls, intestines, gall bladder, lungs and brain; degenerative changes in heart muscle, liver, and kidney; tiny hemorrhages in mucous membrane of the stomach below the visceral pleura and in the epicardium and large hemorrhages in the kidney and the adrenal tissue on the right. The protocols mention the presence of blood in the heart and vessels and an odor of "dried mushrooms" from the internal organs.

The condition of S. on August 20, the second day after poisoning, also worsened somewhat. He complained of severe headache, nausea, periodic vomiting; the skin of the face was moderately cyanosed. Macroscopic examination of the internal organs revealed sensitivity upon palpitation of the abdomen. Loose stools twice a day without mucus or blood and pronounced oliguria.

On August 21, the patient showed signs of improvement. The appetite was restored; he experienced dull pain in the substernal region, nausea and occasional vomiting. Scattered dry rales, twenty respiratory excursions a minute; tongue coated white; abdomen soft, tender upon palpation in substernal regions; liver not enlarged; spleen not palpable; diuresis 600 ml in previous 24 hours with copious fluid intake (about 41 liters).

August 22, mild headache, periodic nausea and vomiting; face somewhat hyperemic, conjunctival vessels congested; no changes in the internal organs; diuresis amounted to 2100 ml during past 24 hours, loose mucus stools 2 or 3 times a day.

August 23 the patient felt better. Vomiting and nausea ceased. The temperature, which had not risen above 37.3°, dropped to normal. Formed stool once a day. Internal organs unchanged. August 24, only general weakness,

¹ In the diagnosis the poisoning was ascribed to the use of brake fluid which often contains methyl or butyl alcohol. However, after other symptoms appeared, antifreeze was considered responsible. The precise chemical composition of the gastric lavage became known only after the patient died.

noise in head, transient pain in substernal region. Heart sounds dull, first sound unclear at apex. Patient began to improve rapidly thereafter. Analysis of the gastric juice on September 7 revealed a slight drop in acidity. September 9, X-rays of the gastrointestinal tract showed no pathological changes.

Both patients received massive treatment of general character aimed at eliminating the poison from the system and at detoxication, as well as active symptomatic therapy.

Table 1 shows how the blood analysis of D. and S. differed on the second day after poisoning. The hemoglobin and erythrocyte content in S. was somewhat higher than in D. Moreover, leukocytosis in S. was more pronounced, evidently indicating the superior reactivity of his organism. It is quite possible, however, that the somewhat larger dose of poison taken by D., which resulted in the suppression of the leukopoietic function of the bone marrow, also had an effect. Eosinophils were lacking in the initial blood analysis of both patients. Within a day blood picture of S. became normal, leukocytosis decreased, neutrophilia disappeared, eosinophils appeared. ESR increased, in

T A B L E 1.

Blood analyses of patients D and S.

Blood indexes	Dates and initials									
	20 August		22 August		23 August		30 August		7 September	
	D	S	D	S	D	S	S	S	S	S
Hemoglobin %	70	78			58	66	75		73	
Erythrocytes in 1000	4,510	4,800			3,570	4,250	4,420		4,680	
Leucocytes	13,200	18,500			11,500	9,100	10,400		8,700	
Color index	0.77	0.81			0.82	0.78	0.85		0.79	
Stabnuclear	13	4			7	0	2		2	
Segmented	67	77			83	59	62		56	
Eosinophils	0	0			0	2	4		4	
Lymphocytes	18	14			4	29	27		31	
Monocytes	2	5			6	10	5		7	
Sed'n rate mm per hour	4	2			3	20	7		4	
Thrombocytes						164,220				
Res. N, mg%			45	30						
Chlorides, mg%			877.5							
Bleeding time					3 min.					
Coag'ln time					7 min.					

TABLE 2.

Urinalysis of patients D. and S.

Urine indexes	Dates and patient's initials							
	20 August		22 August		23 August	24 August	26 August	30 August
	D	S	D	S	S	S	S	S
Specific gravity	1.023	Insuff.	1.015	1.003	1.010	1.010	1.012	1.015
Reaction	Acid	Acid	Acid	Acid	Acid	Acid	Acid	Acid
Albumin, in %	1.48	0.495	4.290	0.230	0.099	0.033	Trace	None
Hyaline casts	One	None	0 - 1	None	None	None	None	None
Granular casts	None	None	1 - 2	None	None	None	None	None
Kidney epithelial cells per field	1 - 2	None	6 - 8	None	None	None	None	None
Leucocytes per micro-field	5 - 6	10 - 15	30 - 50	10 - 15	1 - 2	1 - 2	0 - 1	0 - 1
Erythrocytes per micro-field	3 - 4 fresh	2 - 3 fresh	2 - 3 changed	0 - 1 fresh	1 - 2 changed	1 - 2 changed	None	None
Alkali resistant per micro-field	1 - 2							
Epithelial cells from urinary tract	Some	Some	Occa- sional	Occa- sional	Occa- sional	Occa- sional	Occa- sional	Occa- sional

D., leukocytosis and neutrophilia continued, eosinophils, as before, were lacking. Both patients exhibited a marked drop in the hemoglobin and erythrocyte indexes, particularly so in D. Blood picture of S. gradually returned to normal.

Table 2 shows that kidneys of D. were seriously affected from the beginning, kidneys of S. not as much. After a day pathological changes in the urine of D. continued to intensify, whereas in the urine of S. they steadily decreased and finally became normal.

The sickness took a grave course in D., with major changes primarily in the cardiovascular system. Furthermore, 2 to 3 days after poisoning there was a marked oliguria turning to anuria. The hemorrhagic syndrome appeared on the 3rd day. Finally, on the 4th day, pulmonary edema developed after a reduction in cardiovascular activity, which was the direct cause of death.

The Toxicity of Highly Dispersed Cadmium Oxide Aerosol.

By

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Farmakol. i Toksikol., Vol. 21, No. 2, 72-77, 1958.

The increasing use of cadmium by industries makes imperative the study of its toxic properties, since the aerosol formation of this substance may occur in a number of processes.

In 1949 E. P. Vishnevskaya obtained some data on the comparative toxicity of industrial cadmium dust of different dispersion and of a number of soluble cadmium salts. The results showed that the highly dispersed aerosol of cadmium oxide was highly toxic. The LD_{100} for rats through inhalation for one hour was 0.045 mg/li. The same author and such foreign authors as J. Prodan, H. E. Harrison, H. Bunting, N. K. Ordway, W. S. Albrink and Paterson performed some chronic experiments which showed that cadmium possessed general toxic properties.

The cited reports emphasized the possibility that the cases of industrial poisoning described by Sovet, Weheller, Stephens, Th. M. Legge, L. Schwarz, L. Friberg and others were caused by cadmium. Only two cases of acute industrial poisoning with cadmium were described in the domestic literature, one by V. P. Gaivaronskii and his co-author in 1936, the other by R. S. Vorob'eva in 1953, and one case of sub-acute poisoning was described by V. Demyachenko in 1932. To prevent the occurrence of industrial cadmium poisoning E. P. Vishnevskaya recommended the limits of allowable concentration for a number of cadmium compounds in the air of industrial premises. The recommendations were based on experimental results related to the threshold toxicity of cadmium compounds using morphological changes in the organs of the poisoned animals as toxicity indexes.

The purpose of this study was to find early physiological functional indexes for the timely discovery of cadmium intoxication symptoms, particularly symptoms manifested by the nervous system, so that prophylactic sanitary measures could be instituted without delay. This was accomplished by chronaxic and conditioned reflex studies as described below.

The technique. Animals were placed inside a glass-walled chamber; cadmium oxide was aerosolized by means of an electric arc and was uniformly distributed throughout the chamber by a fan. The animals were free to move about within the chamber. The attained cadmium concentration within the chamber was determined colorimetrically. Changes in chronaxy were studied by means of a condenser-chronaximeter. Flexor and extensor motor chronaxy determinations were made of the right side posterior extremity. Conditioned reflexes were investigated according to Kotlyarevskii's motor-nutritional reflex procedure. Stereotype response was developed in white mice to red light and ringing of a bell and to the sound of a buzzer, which acted as positive and negative stimuli, respectively. Control experiments were made to determine the effect of prevailing experimental conditions upon the functions under investigation.

To accomplish this the animals were placed into the exposure chamber where the electric arc was burning intermittently for one to two hours. Chronaxia and conditioned reflexes were investigated several minutes after quasi poisoning. The results established that the experimental conditions effected no changes either in the chronaxy or in the conditioned reflex activity of the test animals.

Effect of a single exposure to cadmium oxide aerosol upon motor chronaxy and on the conditioned reflex activity. At the outset animals were exposed to one-hour cadmium poisoning of lethal and threshold cadmium oxide concentrations, since no reports were found in the literature which dealt with changes in chronaxy and in conditioned-reflex activity of animals subjected to the effect of cadmium oxide. The concentrations referred to were those established by E. P. Vishnevskaya on the basis of the morphological changes manifested in the organs of the test animals. Changes in chronaxy following exposure to a toxic concentration of 0.063 mg/li appeared immediately after poisoning. The rheobase and chronaxy were enhanced, the rheobase having been affected first. The extensor chronaxy was increased more than the flexor chronaxy. Thus, 70 minutes after poisoning the flexor chronaxy of rat No. 40 increased from 0.015 microfarad to 0.2 microfarad, or thirteen times, while the extensor chronaxy increased from 0.02 microfarad to 0.61 microfarad or thirty times.

The threshold toxic concentration of highly dispersed cadmium oxide aerosol according to Vishnevskaya was 0.02 mg/li, with a concentration of 0.018 mg/li, she found no changes in the organs of the rats. A concentration of cadmium in the air ranging between 0.012 and 0.017 mg/li, i.e., a concentration below the threshold value of acute toxic effect produced no immediate changes in the rheobase or chronaxy. However, after several hours the animals showed signs of dyspnea and asthenia. Only one rat of five showed a slight increase in extensor motor chronaxy.

Studies were also made of the effect on rats' conditioned reflex activity following a one-hour exposure to cadmium oxide aerosol concentrations ranging from 0.013 to 0.018 mg/li. Three rats, with previously developed pattern of motor-nutritional conditioned reflexes were thus tested. During the exposure the animals showed no signs of restlessness and remained active to the end of the experiment.

Considerable disturbance in the conditioned reflex activity of the rats was noted immediately after the exposure. Prolonged latent periods, phase reactions in the conditioned reflex magnitudes and the inactivation of individual reflexes in response to red light and sound of bell were noted. The natural reflex to the appearance and smell of food placed into the feed box persisted during the first hour after exposure. One to two hours later, the behavior of the animals began to change; dyspnea appeared and the animals be-

came inactive. Investigation of the conditioned-reflex activity disclosed that the natural and induced reflexes were entirely absent, and remained absent the day following. On the third day all animals showed signs of restoration of the natural reflexes and they appeared to be in normal health. However, the induced conditioned reflexes remained absent for 5 to 7 days. The disturbance in the conditioned reflexes seemed deep-rooted and was not fully restored for several months. After three and one-half months of rest the higher nervous activity of the animals showed no improvement.

Effect of repeated inhalations of cadmium oxide on conditioned reflex activity and on motor chronaxy of rats. The animals were exposed daily to one-hour inhalation of air containing 0.0018 to 0.002 mg/li of cadmium oxide for three months. The animals were under observation over a period of five months; one month preliminary to the poisoning, three months during the inhalation exposures, and one month following the exposure period. The conditioned reflex activity of the animals was checked every third day, and chronaxy every week. The results of the investigation carried out during the first month have served as the control background. No changes were observed in the general condition and behavior of the animals to end of the observation. The animals remained active, retained their appetite, and in some animals the appetite increased. Some changes in the animals' conditioned-reflex activities were noted during the first month of exposure. Continued exposure resulted in a further decrease of conditioned reflexes of all the animals; this decrease was in progress after the exposures were discontinued; it could be noted in the response to all types of stimulation regardless of its position in the stereotype pattern.

The latent period of conditioned reflex response became more delayed in all animals during the first month of exposure. Changes in the latent period of conditioned reflex response to the sound of the bell and to the red light in the case of rats Nos. 19 and 4, are shown in the following Table.

Rat No.	Type of stimulation	Latent period in seconds (averages of ten tests)				
		Before exposure	First month	Second month	Third month	Fourth month
19	Bell	1.27	1.83	1.56	1.7	1.6
	Red light	4.0	4.4	4.35	7.52	7.88
4	Bell	1.59	1.85	1.66	3.85	4.27
	Red light	4.39	4.5	5.6	5.2	5.03

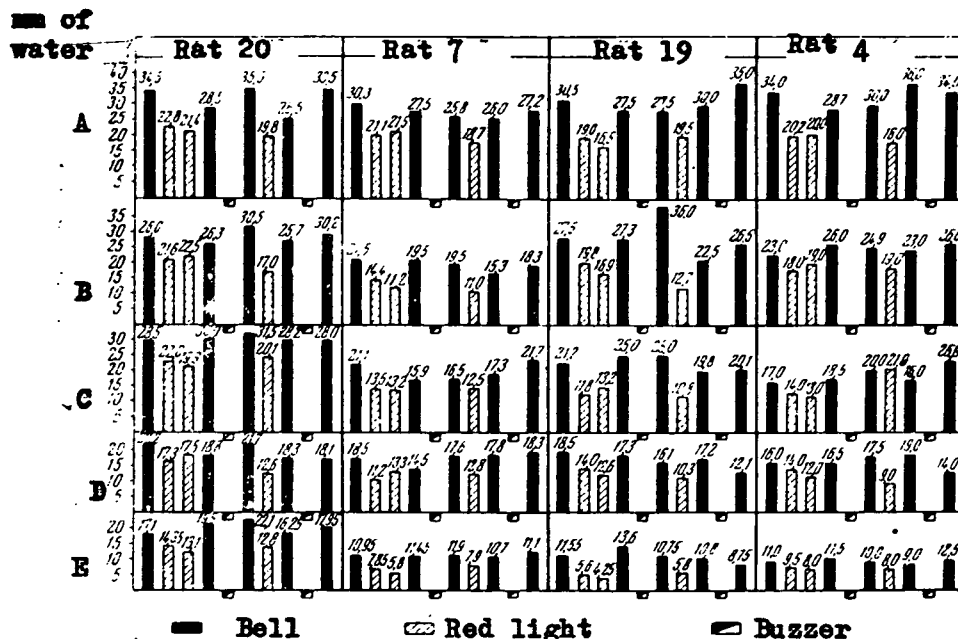


Fig. 1. Changes in magnitude of conditioned reflex response in mm of water in chronic exposure to 0.002 mg/li of cadmium oxide.

A - Month before exposure; 2 - First month of exposure; C - Second month of exposure; D - Third month of exposure; One month after end of exposure.

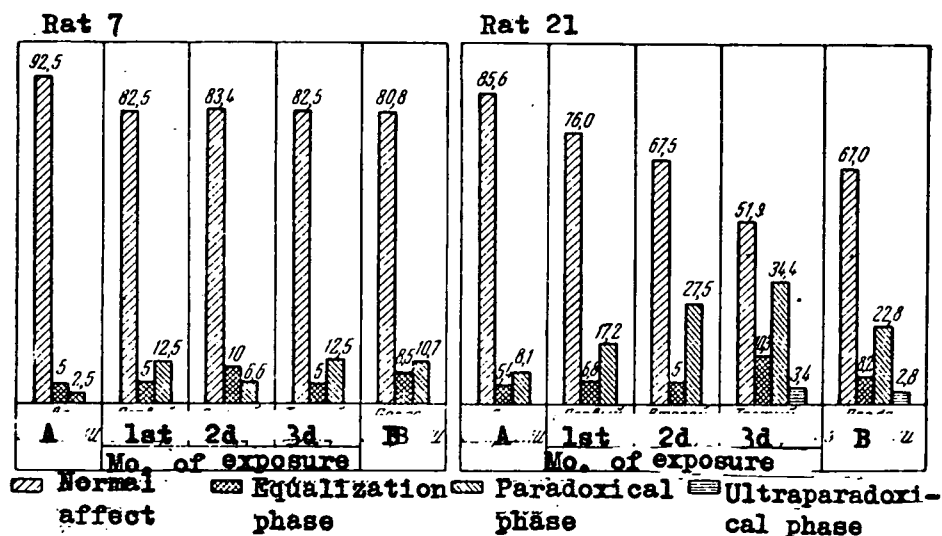


Fig. 2. Percent of phase disturbance in chemical poisoning with 0.0018 mg/li of cadmium oxide.

Periods: A - Before exposure; B - After end of exposure.

Cadmium intoxication brought about an increase in the number of disturbed responses to stimuli of different intensity. The percentage of more deeply-rooted disturbances in the form of paradoxical and ultra-paradoxical phases increased considerably in some animals.

Increasing intoxication was accompanied in some cases by complete disruption of conditioned reflex activity such as a complete fading out of the responses, first to mild stimulation by red light and then to the sound of the bell. Differentiation was followed by the sequence of inhibition.

As the result of intoxication the differentiation of negative stimuli improved in the majority of the animals. After the poisoning was discontinued the differentiation again declined. A prolonged motor chronaxy became detectable at the beginning of the second month of poisoning. In all cases of chronic poisoning by cadmium oxide, in contrast to the cases of acute intoxication, the flexor chronaxy was more prolonged, while the extensor chronaxy either remained without change or was slightly shortened. Prolongation of the chronaxy had undulant characteristics and was moderate. Flexor chronaxy increase from 0.045 to 0.054 microfarad (three times that of the initial value) was observed only in two rats on separate days of the investigation. In only a few animals did the chronaxy return to the normal level at the discontinuation of exposure.

Discussion of the results. Results of the observations demonstrated the high toxicity of condensed cadmium oxide aerosol. The effects of the intoxication in the form of disturbances in the nervous system were discovered earlier than the usual pathologic effects, such as gross morphological histologic changes in the organs of the cadmium poisoned animals. Changes in conditioned-reflex activity appeared first as progressively delayed and diminishing response to stimulation and as inhibited differentiation. However, endogenous inhibition was lowered, as was shown by the fact that even upon weaker stimulation differentiation inhibition concentrated only slightly and at times merged into a light sleep. As the result of the intoxication a state of inhibition developed in the cortex simulating phase hypnosis of the paradoxical and ultra-paradoxical type. The inhibition was of a functional character and acted as a protective inhibition in the initial stage of intoxication.

Functional changes in the nervous system were also determined by the method of chronaxy. According to G. A. Levina a prolonged motor chronaxy and a rheobase increase were indications of lowered stimulability of the motor apparatus. The dissimilarity in the characteristics of chronaxy changes in cases of acute and chronic intoxication may be due to the different intensities of cadmium irritation. Unusually prolonged chronaxy, more pronounced in the extensor group, could be the result of irritation in the region of lung interoceptors,

as was shown by I. M. Wool, Yu. M. Uflyand, O. N. Zamyatina, V. D. Mikhaylova and I. P. Nikitina.

In the opinion of these authors chronaxy changes in cases of chronic poisoning are connected with the development of inhibition processes in the central nervous system; this was substantiated by the results referred to above in relation to conditioned-reflex activity.

Conclusions.

1. Highly dispersed cadmium oxide aerosol inhaled by the living organism can affect the functional state of the central nervous system, which, in turn, will cause disturbances in the conditioned-reflex activity of animals and lower the stimulability of the motor apparatus.

2. A single inhalation of cadmium oxide in 0.013 to 0.018 mg/li, or threshold concentration, as established by pathomorphologic investigations, will disturb the conditioned-reflex activity considerably ahead of the appearance of other intoxication indications. Such changes in the conditioned-reflex activity are to a certain extent irreversible, and can be detected after one hour of exposure to an air concentration ranging from 0.013 to 0.018 mg/li. Such a cadmium concentration range must be regarded as one exceeding the toxicity threshold concentration.

3. Repeated exposure to cadmium oxide in concentrations ranging from 0.0018 to 0.002 mg/li brought about disturbances of the conditioned-reflex activity, without any observable changes in the general condition or behavior of the animals.

4. Disturbances in the conditioned-reflex activity of animals subjected to acute or chronic cadmium intoxication are of similar character and appear as prolonged latent periods, lower reflex responses, and in some cases as hypnotic phases.

5. The nature of chronaxy changes in acute and chronic cadmium intoxication are dissimilar. In the first case the chronaxy changes were more pronounced in the extensor group, and in the second case they were more pronounced in the flexor group.

6. A reverse development in the pathologic condition of the central nervous system, such as improvement in the conditioned-reflex activity and a lowered chronaxy, should be regarded as indicative of the functional origin of some part of the pathologic changes. On the other hand, the slow course of the

reverse process most likely points to the presence of irreversible, possibly morphological, changes in the nervous system.

7. The fact that changes in the functional condition of the central nervous system can be elicited with lower cadmium concentrations in the air than morphological changes in the internal organs, and that the threshold concentration, as established by chronic intoxication of rats is below 0.0018 mg/li, should be taken into consideration in setting allowable concentration limits for cadmium oxide in the air of industrial establishments.

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Hygienic Evaluation of Atmospheric Air in the Vicinity of an Abrasive Plant.

By

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Gigiena i Sanitariya, Vol. 23, No. 11, 22-23, 1958.

The sanitary protection of atmospheric city air from pollution by emissions of industrial plants is an urgent problem of great importance to the government. Abrasive plants emit great quantities of harmful substances containing silicates, and constitute potent sources of deleterious air pollution. Despite that, few publications were found in the literature dealing with the hygienic aspects of the abrasive plants as sources of atmospheric air pollution.

The Leningrad abrasive plant produces abrasive instruments and intermediate abrasive products on a large scale. Recently the plant was rebuilt and its capacity was considerably increased. The raw materials used in the production of abrasive instruments are aluminum, bauxites, clays, feldspars, pegmatites, sodium silicate, boron glass, anthracite and other materials. Some of these materials contain from 55 to 77% of silicates. The crushing, grinding and distribution of the raw material are dry processes which generate and emit great quantities of dust. The manual method of treating these materials, leakage in pipes and conduits and in other equipment and the inefficiently installed and operated dust collectors all contribute to the intense pollution of the air with dust.

In some plants the ventilated exhaust air is emitted into the atmosphere after it had passed through cyclones, which remove nearly 70% of the dust. However, such practices are not general, since many plant departments have no such purifying installations. The abrasive plant throws out into the atmosphere daily 15 tons of fine grain dust, which is a valuable commercial product in itself. The electric smelting department, the boiler room and the kiln department, which emit great quantities of gas, have no gas purifying installations.

During 1955 and 1956 air pollution studies of dust concentrations were determined by the sedimentation and aspiration methods at 3 points - south, north and east. 118 samples were collected by the sedimentation method and 136 by the aspiration method. Results of the latter are presented in Table 1.

T A B L E 1.

Indexes of atmospheric air dust concentrations in $\text{g/m}^2/\text{mo}$
in the surroundings of the plant.

Season of the year	Zones					
	Plant grounds	250 m	500 m	700 m	1000 m	1500 m
Heating	1,867.4	229.7	135.9	110.5	63.5	43.4
Non-heating	1,610.5	238.7	146.0	148.5	60.8	99.1
Averages for entire period	1,732.4	228.4	140.3	125.5	61.4	68.6

The data in Table 1 show that the intensity of dust pollution in the non-heating season of the year was somewhat higher than in the heating season.

At 1500 m from the plant the dust concentration sharply rose during the non-heating season. This can be attributed to the generally dusty surface of the streets and to their poor maintenance. The basic part of the atmospheric dust consisted of inorganic substances such as ash, the content of which fluctuated through the period of observation between 66.2% and 89.2%.

Silicon dioxide was determined in all 118 samples colorimetrically by the Polezhaev method. Depending upon the distance from the plant the average SiO_2 content of the dust ranged from 233 down to 45.2%.

Dust concentrations in atmospheric air were determined in the summer and fall of 1956 at the original five points. Rate of air aspiration ranged between 15 to 20 li/min, and aspiration was continued for 3 hours. Dust concentration data are shown in Table 2.

T A B L E 2.

Dust concentration in mg/m^3
in plant surroundings.

Zones	No. of samples	Concentrations	
		Average	Maximal
Plant grounds	30	13.27	30.7
250 m	33	5.56	27.15
500 m	24	5.36	19.55
700 m	14	2.72	7.03
1000 m	35	0.26	0.62

The maximum single atmospheric air dust concentration near the plant exceeded the permissible concentration limit.

Concentration of SO_2 in the air was determined nephelometrically in 148 air samples. The results are shown in Table 3. The maximum single concentration of SO_2 exceeded the permissible concentration limit. The subjective question and answer

T A B L E 3.

Sulfur dioxide concentrations in mg/m^3
in plant surroundings.

Zones	No. of samples	Concentrations		
		Minimal	Maximal	Average
Plant grounds	30	0.28	3.08	1.07
250 m	31	0.12	3.8	0.58
500 m	30	0.21	2.4	0.43
700 m	28	0.13	4.7	0.54
1000 m	29	0.1	0.88	0.32

method was also conducted including 300 persons. Considerable complaints of dust and smoke in the atmospheric air were registered at 1000 m from the plant. Residents living at a radial distance of 1500 m from the plant registered no complaints related to dust pollution.

A study was also made of the incidence of diseases

among children up to 15 years old for the year 1955, based on their visits to the polyclinic. Two areas were thus investigated, and records were entered on special cards: one area close to the plant and the other a control area 5 km from the plant, the air of which was polluted by discharges from other types of industrial plants. The dust concentration ranged between 0.29 and 3.94 mg/m^3 and SO_2 between 0.13 and 1.0 mg/m^3 . General and home living conditions and family incomes of the two areas were practically of same levels.

1900 cards were collected in the plant area and 2190 in the control area.

Incidence of children's diseases in the plant area was higher than in the control area.

Conclusions.

1. The abrasive plant constituted a considerable source of atmospheric air dust pollution; it contained free silicon dioxide and sulfurous gas.
2. The plant emissions had a deleterious effect on the sanitary and general living conditions of the residents.
3. To prevent the harmful effect of the abrasive plant discharges on the sanitary condition of the populated areas, it is necessary: a) to adopt a wet system of raw material crushing; b) to prevent dust leakage from dust generating departments; c) to install dust and gas purifying equipment; and d) to improve the grounds and to plant trees and shrubs around the plant and in the adjacent vicinity.
4. The sanitary-protective zone must be not less than 1000 m wide.

The results of this investigation were handed in to the R.S.F.S.R. Ministry of Health by the Leningrad Sanitary Organization.

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Determination of Limit of Allowable Concentration of Hydrochloric Acid Aerosol (Hydrogen Chloride) in Atmospheric Air.

By

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Gigiena i Sanitariya, Vol. 24, No. 1, 13-20, 1959.

Hydrogen chloride is a colorless gas having a strong peculiar odor; it is usually present in the atmosphere in the form of hydrochloric acid aerosol; it is highly hygroscopic. Hydrochloric acid is widely used in many branches of the national economy and ranks fourth among the inorganic acids. Plants which manufacture and use hydrochloric acid are potent factors in the pollution of atmospheric air with its aerosol. Hydrogen chloride is thrown into the atmospheric air along with other pollutants by plants producing titanium, magnesium, silico-organic compounds, such as resins and insulation lacquers, explosives, dyestuffs, zinc chloride, etc.

Hydrogen chloride penetrates into the workshops, heavily polluting the indoor air. According to A. G. Aver'yanov, B. I. Gurvich, B. B. Bykhovskii, V. Ikryannikov, A. I. Smirnov, G. Ya. Klebanov and I. L. Izrailovich, F. S.

Branenburg, T. S. Karacharov, L. Skhol'-Engberts and others, the concentration of hydrochloric acid aerosol in shops varies from 5 to 365 mg/m³. Shop ventilation systems discharge into the atmosphere air which is heavily polluted with hydrochloric acid aerosol. The amount of hydrogen chloride emitted into the atmosphere by industrial plants depends upon the technological process used and on the gas purifying equipment, without which the emitted hydrogen chloride may amount to 15 tons in 24 hours.

Despite the fact that sources of atmospheric air pollution with hydrochloric acid aerosol are numerous, the problem has not been studied sufficiently and the limit of its allowable concentrations have not been determined. In determining the degree of atmospheric air pollution with hydrochloric acid aerosol use was made of the recently developed method for the differential determination of simultaneously present chlorides and sulfuric acid in the air. The interfering effect of chlorides was eliminated by micrometric titration of solutions of hydrochloric acid with an 0.005 N solution of sodium hydroxide; the control and the test sample were of same volumes and contained the same amount of methyl violet as the indicator. The sensitivity of the method was 0.002 mg. This titrimetric method was not specific for hydrochloric acid, because other acids interfered with the determination. Since SO₂ and sulfuric acid were present in the atmospheric air frequently, their quantitative presence in the air was determined nephelometrically by the barium chloride method and subtracted from the total acid value obtained by the method of titration. Air samples were aspirated at the rate of 1 li/min through fresh, twice distilled water contained in V-shaped absorbers equipped with glass filters No. 1.

The studies of air pollution with hydrochloric acid aerosol were made in the immediate vicinity of four plants. In 75 percent of the air samples collected in the proximity of the three plants equipped with gas purifiers the concentration of HCl aerosol in the air was below the sensitivity of the method. The fourth, a magnesium plant, had no gas purifying equipment, and the picture of air pollution presented by the analyses of air samples collected in its proximity was considerably different. Results of air sample analyses are shown in Table 1.

The results show that single maximal concentrations of hydrochloric acid aerosol were of considerable magnitude even as far as 2 to 3 km from the side of the plant. Residents of the area where samples were collected complained

of a constant noxious odor and of the deleterious effects of the plant emissions on the trees, shrubs and garden vegetables.

T A B L E 1.

Maximum single concentration of HCl aerosol around the magnesium plant.

Meters from plant	Number of samples	Number of samples below the sensitivity of the method	Concentration in mg/m^3	
			Maximal	Average
300	39	3	4.4	1.77
500	44	1	10	3.7
800	43	7	34	4.7
1,000	49	-	34	6.1
2,000	32	5	17.3	5
3,000	34	1	17.3	5.4
Totals	241	17		

The effect of low concentrations of hydrochloric acid aerosol on the physiological reactions of man was studied by the method of olfactory threshold (odor) perception. This study was conducted according to the procedures recommended by the Committee for the Determination of Limits of Allowable Air Pollutants. The determination of the threshold value of olfactory (odor) perception was conducted with the aid of 13 persons 19 to 42 years of age, on whom 336 tests were made. The results showed that in 69% of the persons the threshold perception concentration of hydrochloric acid aerosol was $0.2 \text{ mg}/\text{m}^3$, while 23% of the persons tested perceived the aerosol odor at $0.1 \text{ mg}/\text{m}^3$. The practice in the U.S.S.R. has been to accept the lowest experimental value as the standard. It is, therefore, recommended that $0.1 \text{ mg}/\text{m}^3$ be accepted as the olfactory threshold concentration of HCl aerosol.

I. P. Pavlov pointed out that the cortical elements of the different analyzers were intercommunicative and interdependent and could not be examined independently of one another, since any stimulus or effect which changed the functional state of one affected all other analyzers and their elements through reflex effects. Hydrochloric acid aerosol penetrated into an organism chiefly through the respiratory organs, thereby affecting and irritating the mucous membranes of the respiratory tract; therefore, it was decided to study the effect of low concentrations of hydrochloric acid aerosol upon the central

T A B L E 2.

Determination of threshold of odor perception of
hydrochloric acid aerosol.

Subjects' initials	Concentration in mg/m^3	
	Minimal perceived	Max. not perceived
A. A.	0.2	0.1
B. B.	0.3	0.2
B. M.	0.2	0.1
G. O.	0.1	0.05
D. F.	0.2	0.1
E. G.	0.2	0.1
E. V.	0.1	0.05
K. E.	0.2	0.1
L. A.	0.2	0.1
M. T.	0.2	0.1
S. V.	0.1	0.05
F. G.	0.2	0.1
Ya. T.	0.2	0.1

nervous system, through the reflex generating zones of the respiratory organs. Tests were made for the determination of effects on optical chronaxy, dark adaptation, and by the methods of plethysmography and pneumography.

Tests for the determination of reflex transmission of hydrochloric acid aerosol odor effects on optical chronaxy were conducted on three persons with the aid of a GIF chronaximeter, 1949 model. The threshold value of olfactory perception by this reflex method was at $0.2 \text{ mg}/\text{m}^3$ concentration, which is practically identical with the results previously discussed. The observations were conducted in a darkened room. The eyes of the test persons were closed and each observation lasted 27 minutes. For a period of 11 - 14 minutes prior to the persons' exposure to the HCl aerosol odor, control tests were made at 3 minute intervals for the determination of the values of each person's normal rheobase and chronaxy. Hydrochloric acid aerosol in known concentrations was then inhaled by the test person. Rheobase and chronaxy determinations were made and recorded immediately at the termination of the HCl aerosol inhalation. The test was repeated three times at intervals of 3 to 4 minutes. A total of 639 tests were made using five different aerosol concentrations, namely: 0.2, 0.4, 0.6, 1 and $1.5 \text{ mg}/\text{m}^3$. The results indicated that inhalation of hydrochloric acid aerosol in 0.6 to $1.5 \text{ mg}/\text{m}^3$ concentrations shifted the value of optical

chronaxy, while 0.2 to 0.4 mg/m^3 concentrations produced no appreciable effect. In two cases, 1.5 mg/m^3 of the aerosol prolonged the chronaxy of 0.15 to 0.2 μF , and in one case it was shortened by 0.1 μF . As the HCl aerosol concentrations were lowered, the shifts in the optical chronaxy decreased. A concentration of 0.6 mg/m^3 prolonged the chronaxy of all tested persons only by 0.04 to 0.08 μF .

Results of statistical analysis of the data verified the reliability and significance of the shifts in optical chronaxy caused by the inhalation of hydrochloric acid aerosol in concentrations exceeding 0.6 mg/m^3 . Thus, the threshold of reflex effect of hydrochloric acid aerosol, determined by the method of optical chronaxy was higher than the one obtained by olfactory perception, and, on the basis of the experiments herein described, was equal to 0.6 mg/m^3 .

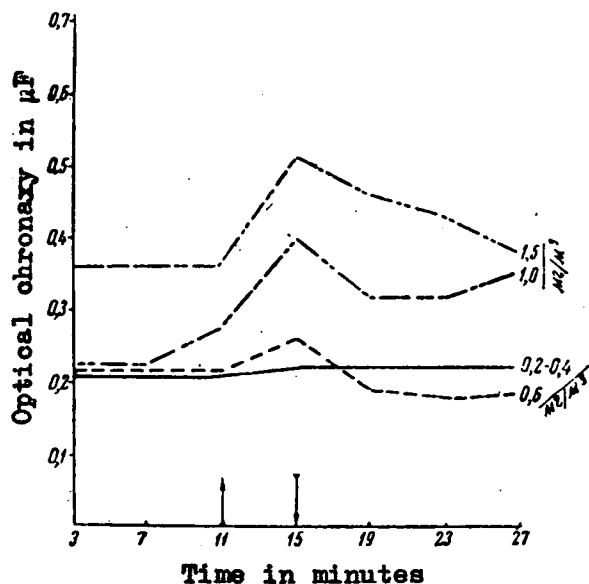


Fig. 1. Effect of different HCl aerosol concentrations on chronaxy of female M.

to the experimental conditions. For control and comparison purposes the normal curve of dark adaptation was established by tests based on the inhalation of pure air; this was followed by tests for the determination of changes in dark adaptation following the inhalation of air containing known concentrations of HCl aerosol.

In the first series of the experiment the test subjects inhaled either pure air or hydrochloric acid aerosol for 15 minutes before dark adaptation determinations were made, using the following four concentrations: 0.05, 0.2,

The effect of low hydrochloric acid aerosol concentrations on the functional condition of the cerebral cortex was studied next by the method of dark adaptation. Observations related to changes in eye sensitivity to light following the inhalation of hydrochloric acid aerosol were conducted on four persons of normal vision and odor sensitivity whose olfactory threshold value as determined by control tests was 0.2 mg/m^3 .

The investigation of eye sensitivity to light was preceded by preliminary training to accustom the subjects

0.56 and 1 mg/m³. During the second series pure air or hydrochloric acid aerosol were inhaled for 4 1/2 minutes beginning the 15th minute after dark adaptation. The HCl aerosol concentrations used were: 0.2, 0.5, 1, 2, 3.2, 5 and 10 mg/m³. Results of the first series showed that inhalation of hydrochloric acid aerosol in 0.05 mg/m³ concentration caused no changes in the course of the dark adaptation curve, as compared with the control curve. The 0.2 mg/m³ concentration sharply reduced the eye sensitivity to light. The 0.56 mg/m³ concentration reduced the eye sensitivity to light of 3 test persons and increased it in one person, K. The results obtained with subject G are shown in Fig. 2.

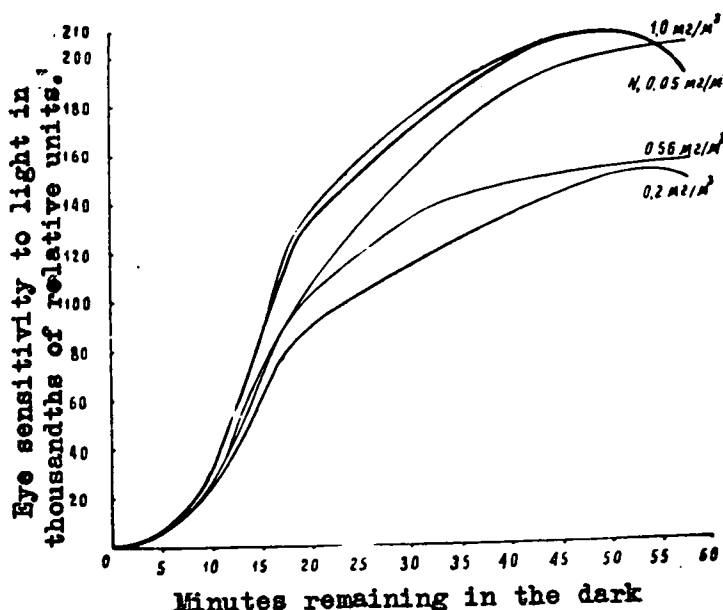
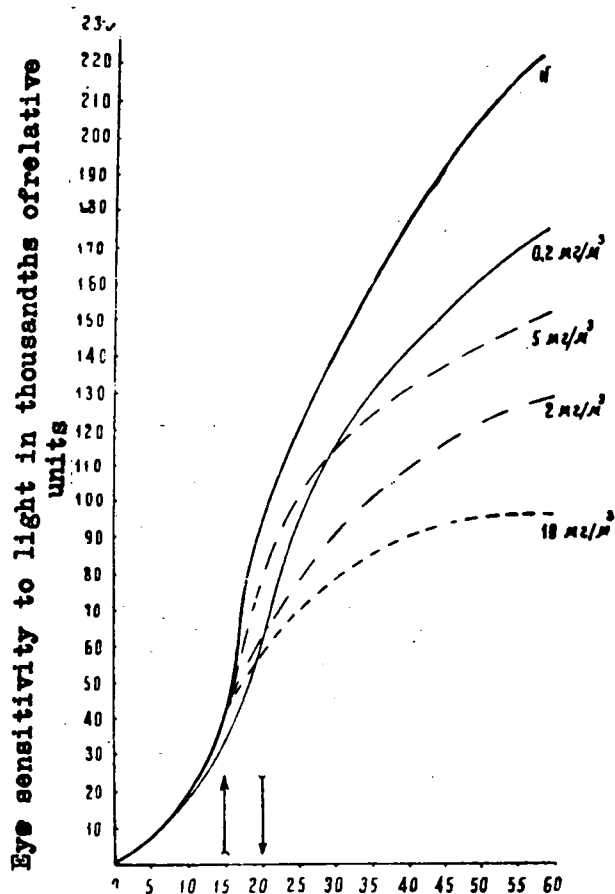


Fig. 2. Changes in eye sensitivity to light after 15 minutes inhalation of different HCl aerosol concentrations by female G before dark adaptation.

In the second series of tests concentrations ranging from 0.2 to 10 mg/m³ decreased the eye sensitivity to light in all test subjects. The changes in the course of the dark adaptation curve, at the 20th minute, i.e., after 4 1/2 minutes of inhalation of aerosol of hydrochloric acid in 0.2 - 10 mg/m³ concentration were verified statistically.

Thus, the olfactory threshold concentration of 0.2 mg/m³, previously arrived at by the subjective method of inquiry, brought about reflex changes in the functional condition of the cerebral cortex, as shown by changes in the course of the curve of dark adaptation in both series of observations. A concentration of 0.05 mg/m³ not perceived by the olfactory organ had no



Minutes remaining in the dark
 Fig. 3. Changes in eye sensitivity to light after inhalation of different concentrations of HCl aerosol by female G during the process of dark adaptation.
 (Arrows indicate intervals of inhalation)

the frequency and amplitude of pulse waves. The following HCl aerosol concentrations were used: 0.1, 0.5, 1.0, 5.0 and 7.5 mg/m³. Results of the experiment showed that inhalation of hydrochloric acid aerosol in 0.1 mg/m³ concentration produced no changes in the plethysmogram. Beginning with 0.5 mg/m³ concentration insignificant rise in tonus was observed at times, but predominantly no changes were recorded in the course of the exposure. At the end of the exposure the plethysmogram showed a depression which reached a maximum of 10 - 12 - 18 mm after 10 to 20 seconds. This depression is a transient one; after 30 to 40 seconds the plethysmogram returns to its initial level. The effect of 1 mg/m³ concentration produced two-phase changes: a rise of the

effect on the sensitivity of the eye to light. Results of supplemental tests showed that five-minute inhalation of 10 mg/m³ HCl aerosol concentration, which is the limit of allowable concentration for the air of working premises, notably decreased the sensitivity of eyes to light.

Effect of HCl aerosol inhalation on changes in vascular reactions were studied in three persons 23, 25 and 26 years of age, using a triple adapter finger plethysmograph, type 3P-2. In this case exposure to the hydrochloric acid aerosol was reduced to 30 seconds.

Observations were limited to changes in the blood volume of the finger blood vessels and changes in

plethysmogram during the exposure and a fall upon the termination of the exposure to hydrochloric acid aerosol, which was more prolonged and of greater negative amplitude than the fall caused by exposure to 0.5 mg/m^3 concentration. The effects of 5 and 7.5 mg/m^3 concentrations also produced two-phase changes: a rise up to 6 or 7 mm at the time of exposure, followed by a gradual fall to a considerably lower level and over a considerably longer period of time; it fell by 12 to 20 mm and returned to the initial level after 1 to 2 minutes.

The pulse rate generally lost 4 to 12 beats per minute during the exposure. During the fall of the plethysmogram, the pulse amplitude increased by 1 - 2 mm; during the rise of the plethysmogram, the pulse amplitude decreased by 1 - 2 mm as compared with the control. The plethysmogram of subject L was obtained at 0.5 mg/m^3 HCl aerosol concentration. It is shown in Fig. 4.

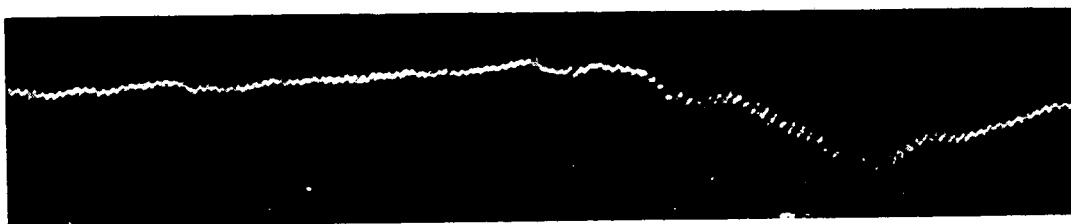


Fig. 4. Changes in the plethysmogram of female L during the inhalation of 0.5 mg/m^3 of hydrochloric acid aerosol.

Inhalation of hydrochloric acid aerosol in 0.1 to 0.2 mg/m^3 concentrations, which is the olfactory threshold value, affected the rhythm and the depth of respiration, as was indicated by the decrease in the number of respiratory waves, increased or decreased amplitudes, rapid exhalation, and retarded inhalation. Increase in the HCl aerosol concentration enhanced the respiratory changes. Two pneumograms are shown in Fig. 5.

The results of the experiments are summarized in Table 3.

The data in the Table show that the threshold values of olfactory perception and changes effected in the rhythm and amplitude of respiration can be used in determining the limits of allowable concentrations of HCl aerosol in atmospheric air. In accordance with the adopted practice of making provision for a coefficient of safety, it is recommended that 0.05 mg/m^3 be adopted as the limit of allowable HCl aerosol concentration in atmospheric air.

Conclusions.

1. The method described allows the differential determination of hydro-

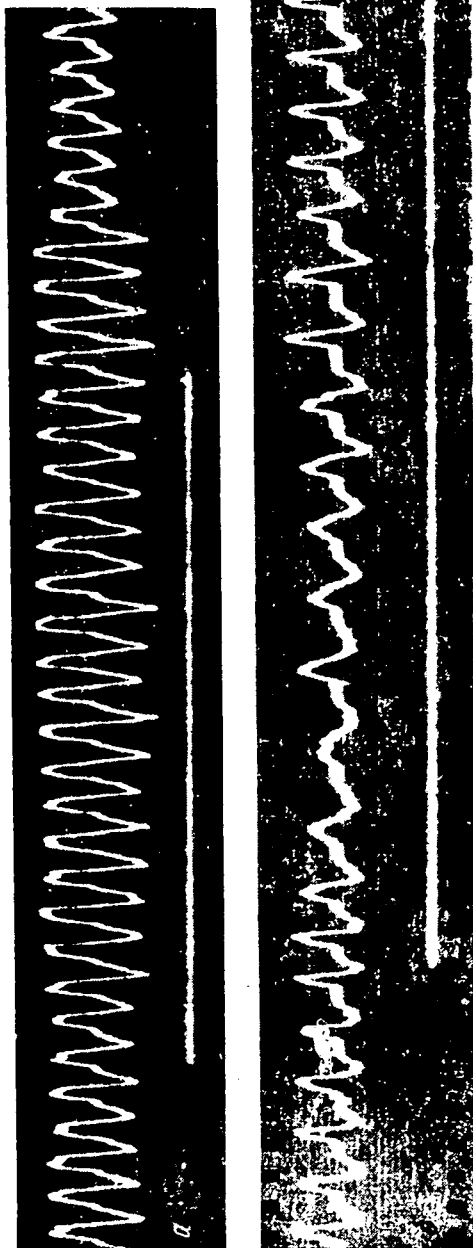


Fig. 5. Changes in the pneumogram during the inhalation of 0.5 mg/m^3 of hydrochloric acid aerosol: upper - by male C; lower - by female K. White lines indicate inhalation intervals.

chloric acid aerosol in the presence of chlorides and aerosol of sulfuric acid.

2. It is recommended that 0.05 mg/m^3 concentration be adopted as the limit of allowable HCl aerosol concentration in atmospheric air.

3. In planning and building new magnesium plants, mandatory provision should be made for the simultaneous installation of appropriate gas purifying equipment.

4. It was demonstrated that hydrochloric acid aerosol was present in the air 2 to 3 km or farther away from the source of emission. It becomes imperative, therefore, that the sanitary clearance zone be widened for the more effective protection of the atmospheric air.

T A B L E 3.

Results of experimental investigations threshold reflex effects of hydrochloric acid aerosol.

Threshold of reflex effect and method of its determination	Threshold concentration of HCl aerosol in mg/m ³
Threshold of odor perception	0.1 - 0.2
Threshold of eye electrical stimulation by the method of optical chronaxy	0.6
Threshold of eye sensitivity to light	0.2
Threshold effect on vascular reaction by the plethysmographic method	0.5
Threshold effect on respiration by the pneumographic method	0.1 - 0.2

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The Determination of Limits of Allowable Concentration of Lead
Sulfide in Atmospheric Air.

By

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The $0.7 \text{ } \gamma/\text{m}^3$ limit of allowable lead concentration in atmospheric air was arrived at by arbitrary calculation. It was adopted as a temporary expedient to be changed at some future time upon the accumulation of basic data. The present work was undertaken for the purpose of obtaining experimental data to serve as the basis for the determination of the limit of allowable concentration of lead sulfide in atmospheric air. The work was done on the basis of chronic experiments, following the procedures and methods recommended by the Committee on Limits of Allowable Concentrations of Atmospheric Pollutants. The toxicity of lead sulfide was studied clinically and experimentally by such authors as N. Yu. Tarasenko, S. P. Kipiani, D. Kober and V. Hansen, L. V. Shraiber, Kh. Z. Lyubetskii and others. However, these authors were concerned mainly with the effect of large lead sulfide concentrations.

No reports were found in the literature dealing with concentrations of lead sulfide in the atmospheric air of lead ore mines or of lead ore processing plants. The study of this question is of particular importance from the viewpoint of community sanitation, since in addition to workers employed in the mentioned enterprises, residents of the surrounding area are also chronically exposed to the effect of lead sulfide. In this connection studies were made of concentrations of lead sulfide in atmospheric air, its contents in the soil, in drinking water, in some food products and in the urine of man. To determine the degree of atmospheric air pollution with lead sulfide samples were collected at stationary points by the aspiration method at 250, 400 and 500 m from the lead ore processing plant. Quantitative lead determinations were made by the chromate method of N. G. Polezhaev. The observations were conducted during one spring and two summer seasons, and 134 samples were analyzed. Results are shown in the following Table.

A study of meteorological conditions indicated that the dispersion of lead dust in the air varied with weather conditions, velocity and direction

**Concentrations of lead sulfide in the atmospheric air,
in terms of mg/m^3 of lead**

Meters from concentration plant	Samples	Dust in mg/m^3		Lead in mg/m^3			% of Pb in dust
		Max.	Ave.	Minim	Maxim	Ave.	
250	36	3,35	1,24	0,0003	0,0484	0,0188	1,51
400	36	2,82	0,84	0,0002	0,0205	0,0051	0,6
500	36	1,60	0,69	0,0002	0,0079	0,0013	0,2
Ave. over village territory	—	—	0,92	—	—	0,0084	0,9
Over territory of plant	26	4,76	2,02	0,0019	0,1348	0,0509	2,5

of the wind, and degree of precipitation. The dust in the atmospheric air consisted of particles 79.16% of which were up to 5μ in size. Lead content in washings from the inner side of window panes indicated that lead dust penetrated into the dwellings. At 250 m from the ore processing plant the lead content amounted to $1.07 \text{ mg}/\text{m}^2/24 \text{ hrs}$; at 400 m it was $0.73 \text{ mg}/\text{m}^2/24 \text{ hrs}$, and at 500 m - $0.19 \text{ mg}/\text{m}^2/24 \text{ hrs}$.

An increased content of lead was noted in the soil within the community area. Top soil scrapings contained 5.07 - 19.47 mg per 100 g of dry soil, and subsoil contained 1.51 - 5.8 mg/100 g of dry soil. A degree of parallelism was noted between the concentration of lead in the atmospheric air and its content in the soil. Results of drinking water analyses indicated that lead in the water did not exceed 0.01 mg/li, which is 10 times below the permissible maximum. A somewhat higher lead content, as compared with data obtained by other authors, was noted in some vegetable and other products of local origin.

Lead in 0 to 0.06 mg/li concentrations was found in the urine of 60 persons of different sex and age whose occupations did not bring them in contact with lead compounds; in 37.5% of the examined persons the lead in the urine amounted to 0.02 mg/li; in 21.5% it was 0.04 mg/li, and in 10% it was 0.06 mg/li. In 30% of the persons examined, lead in the urine exceeded the physiological maximum of 0.03 mg/li.

No reports were found in the literature of the chronic effect of inhaled small lead sulfide concentrations on the central nervous system of animals.

Hence, studies were made of the effect of small lead concentrations on the higher nervous activity of animals as manifested by changes in motor-food conditioned reflex response. The tests were conducted on white rats by the "dynamic exposure" method. Animals were exposed in a special chamber six hours daily, with the exception of non-working days, for a period of six months. Dust of the lead concentrates used contained 49.02% of lead, 10.25% of zinc, 21.8% of silver and 2.37% of SiO_2 .

Animals were exposed in a special experimental two-compartment dust chamber of 100 li. Average lead concentration in the exposure chambers in the first series of tests was $13.5 \text{ } \gamma/\text{m}^3 \pm 0.36$ and $48.3 \text{ } \gamma/\text{m}^3 \pm 0.75$ in the second series of tests. The fluctuations in the dust concentrations were practically insignificant. Check tests established that the dust of the lead concentrate was uniformly distributed throughout the chamber. 86.6% of the dust particles measured between 1 - 5 μ .

Conditioned reflex patterns were developed by the Kotlyarevskii method. Ten white rats of same sex and age weighing 95 - 135 g were used in the experiment. Three types of conditioned reflexes were developed in the animals: two positive in response to sound of bell and red light, and one negative, or differentiation, in response to sound of buzzer. These reflexes formed an organized stereotype of definite sequence: two positive in response to sound of bell; two positive in response to red light; one negative in response to sound of buzzer; two positive in response to sound of bell, and two positive in response to red light. The neuropatterns of the animals were determined by the method of intermittent extinction of the conditioned reflexes, prolongation of differentiation time to 3 minutes and 24 hours starvation. After the neuropattern has been determined, the test rats were divided into three series: animals of the first series of 4 rats were exposed to lead concentration of $13.5 \text{ } \gamma/\text{m}^3$; animals of the second series of 4 rats were exposed to $48.3 \text{ } \gamma/\text{m}^3$ concentration, and animals of the third series of 2 rats were kept as controls.

After 6 months exposure rats of the second series showed the following changes in their conditioned reflex activity: differentiation inhibition release; some increase in the latent period of conditioned reflex response; phase phenomena of compensating and paradoxical nature. Degree of changes varied with the pattern of higher nervous activity of the animal. Thus, changes in the conditioned reflex activity of rats of weak and strong unbalanced neuropattern appeared sooner and were more clearly expressed than in rats of the

strong balanced neuropattern. Paradoxical phases were observed only in rats of a weak neuropattern. Normalization of conditioned reflex activity after exposure discontinuation proceeded faster in animals of the strong balanced type than in animals of the weak type.

Results of conditioned reflex activity studies of two rats are presented in Figs. 1 and 2. The following time data are plotted along the abscissas: 10 days before exposure; 158 days of exposure, and 27 days of recovery. The following are plotted along the ordinate: the upper two curves represent magnitudes of conditioned motor reaction in millimeters; the two curves below represent values of latent periods of conditioned reflex responses in seconds (unbroken lines for the bell and dotted lines for the light), the middle line (BB) marks the differentiation to the buzzer sound. The vertical lines mark the differentiation inhibition release. The curves below the mid-line record the post differentiation indexes. Reactions to all stimulation, except the first bell sounds, are recorded in both Figs. 1 and 2. Each curve represents the mean arithmetical sum of the data obtained in the study of two reflexes. Thus, the first unbroken curve represents the mean value of the conditioned motor reaction to the second and third bell and the dotted line to 1st and 2nd light. Corresponding indicators are presented by the lower curves for the fourth and fifth bell sound and for the third and fourth light.

It is seen from Fig. 1 that changes in conditioned reflex activity in rat No. 7 (second series) began with the appearance of differentiation inhibition release; beginning with the 30th day after exposure; the latter appeared only occasionally and after the 131st day almost daily. Isolated cases of disturbed correlation in the force of response akin to equalization phase and some increase in the latent conditioned reflex response were noted during the last experimental period. Conditioned reflex activity in animals of the second series was fully restored before the end of the recovery period (see Fig. 1), indicating that changes in the higher nervous activity of the animals were functional and reversible.

In the case of animals of the first series, which were exposed to $13.5 \text{ } \mu/\text{m}^3$ of lead, no changes in the higher nervous activity were noted, as can be seen in Fig. 2. Thus, during the entire period of exposure of rat No. 1 differentiation inhibition release manifested itself only 3 times; however, this phenomenon was seen in the animal before exposure as well. Records of rats of the first series presented a similar picture. On this basis it was assumed

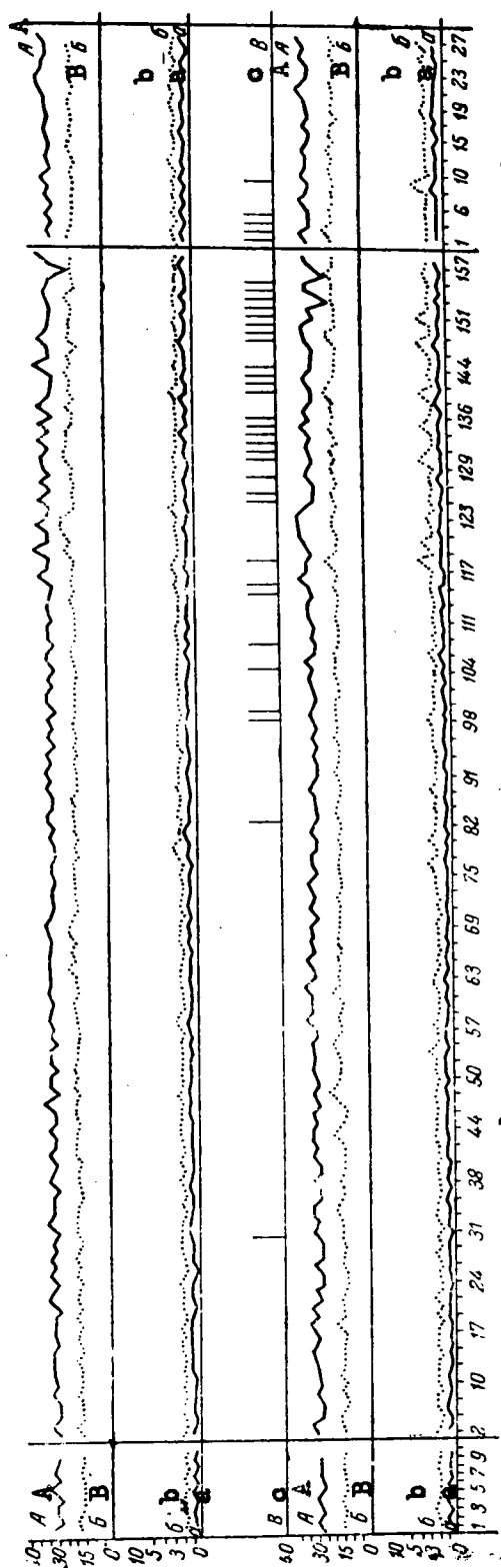


Fig. 1. Effect of $48.3 \text{ } \mu\text{m}^3$ of lead sulfide on the conditioned reflex activity of rat number seven. Average magnitude of conditioned reflex motor reaction: A-A in response to bell, B-B to light; Average latent period of conditioned reflex response: a-a to bell, b-b to light, c-c differentiation response to buzzer.

that some cases of differentiation inhibition release, which appeared in the course of exposure, were not the result of lead dust inhalation. Exposure of animals to lead dust concentrations used in the chronic experiments had no effect on the animals' gain in weight.

Histopathologic examinations were made of tissues of the heart, liver, kidneys, lungs and brain. Morphological changes were seen in the brain and lung tissues. Changes found in other organs were insignificant and practically identical with changes in some organs of rats of the first, second and control series. Symptoms of pneumonia were found in the lungs of rats of the first and second series; in the lungs of rats of the second series sections were seen of hemorrhagic pneumonia, panbronchitis, some vascular necrosis, etc. Microscopic examination of brain tissue showed dystrophy symptoms of single ganglionic cells, mostly of the pyramidal type, in the third and fifth layers of the cerebral cortex. Such changes appeared more clearly in rats of the second series.

Results of blood analyses made after six months inhalation exposure revealed no changes in

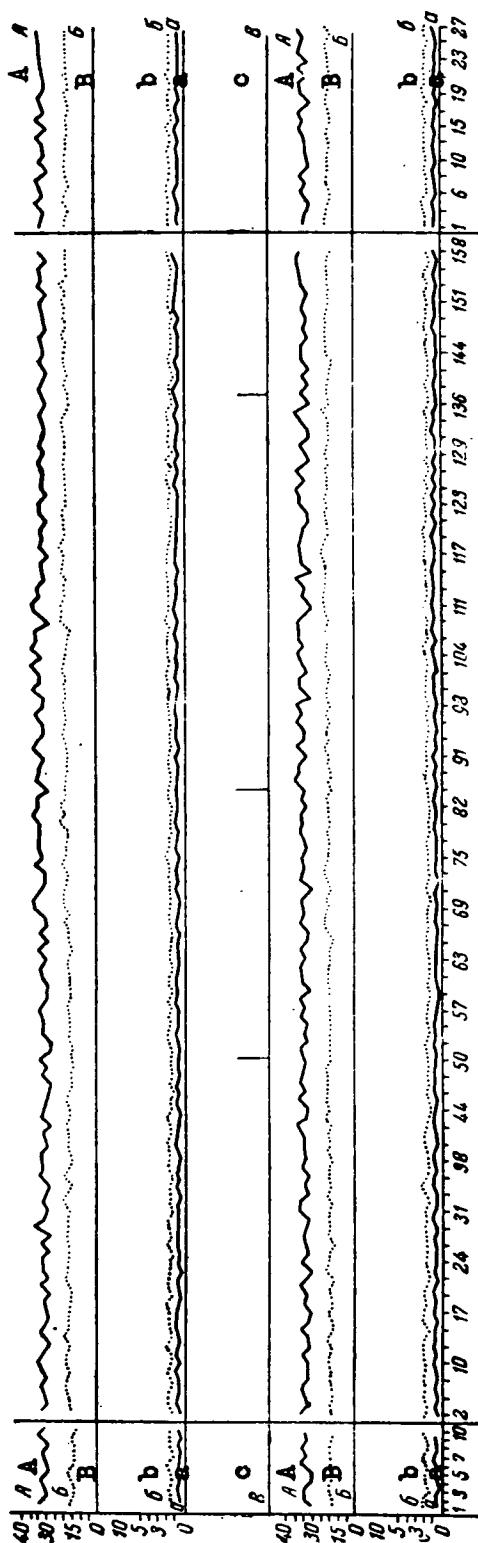


Fig. 2. Effect of $13.5 \gamma/m^3$ of lead sulfide on the conditioned reflex activity of rat number one. Average magnitude of conditioned reflex motor reaction: A-A in response to bell, B-B to light; Average latent period of conditioned reflex response: a-a to bell, b-b to light; o-o differentiation response to buzzer.

the red blood cells of the first and second series, and no basophilic granulo erythrocytes were noted in the blood of any of the animals. The number of leucocytes remained practically normal, with the exception of rats of the first and second series, the leucocytes of which showed a slight numerical rise; as is illustrated by the following: leucocytes in the blood of control rats fluctuated between 8200 - 8600 per 1 ml; in the first series of rats the range was between 10,100 - 12,200 and in second series between 15,500 - 17,400 per 1 ml.

Results of spectral analyses showed that the average lead content in the bone tissue of the second series of animals was five times as high as in the control animals, ranging between 6.5 and 10 mg%. In bone tissue of the first series of rats the lead content was likewise increased, but did not exceed 3 mg%, thus showing an average lead content 1.7 times greater than in the control animals.

Thus, it is seen that under a lead sulfide concentration equivalent to $13.5 \gamma/m^3$ of pure lead, only some of it was retained by the organism; the accompanying histopathological changes in in-

ternal organs were negligible. This concentration can be considered as near-liminal, but not entirely harmless. It must be borne in mind that daily exposure lasts only six hours and that lead possessed the tendency to accumulate in the organism, which necessitates the introduction of an accumulation coefficient; taking the above into consideration, it is suggested that $1.7 \text{ } \gamma/\text{m}^3$ of lead sulfide be adopted as the limit of its allowable atmospheric air concentration.

Conclusions.

1. Lead dust was found in the atmospheric air in the proximity of primary lead ore processing plants. At 400 m from the plant the average dust concentrations in terms of lead ranged between $0.0051 - 0.0013 \text{ mg}/\text{m}^3$.
2. High lead sulfide concentrations in atmospheric air brought about its increase in the urine and should not be looked upon with indifference.
3. Daily exposure to lead sulfide dust of $48.3 \text{ } \gamma/\text{m}^3$ concentration in terms of lead for 6 hours over 6 months brought about a gradual development of functional changes in the conditioned reflex activity, some histopathologic changes in the brain and lungs, and a definite accumulation of lead in the bone tissue.
4. Similar chronic exposure to $13.5 \text{ } \gamma/\text{m}^3$ concentration of lead resulted in some lead retention in the organism and brought about negligible pathomorphological changes in some organs. $13.5 \text{ } \gamma/\text{m}^3$ of lead can be regarded as a near liminal concentration.
5. On the basis of this investigation it is suggested that $1.7 \text{ } \gamma/\text{m}^3$ be adopted as the limit of allowable concentration of lead sulfide in atmospheric air, which is 2.4 as high as the existing limit set for other inorganic lead compounds and is considerably lower than the chronic experimental concentrations which brought about changes such as were described above.
6. For the improvement of sanitary-hygienic living conditions of those who reside near plants engaged in primary lead ore processing, and for the prevention of direct harmful effects of lead dust, sanitary clearance zones not less than 500 m wide should be introduced without delay.

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Effect of Garages and Filling Stations Located in Residential Sections
on Health and Living Conditions.

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Residential pollution can be caused by faulty sanitary-technical equipment such as gas appliances, heating installations, etc., and by sources of atmospheric air pollution located within the area of the community. Sanitary community surveys showed that automobile garages located within residential areas constituted a potent source of air pollution. Sanitary investigations of selected Moscow residential properties indicated that of 1042 garages located in the residential area and housing up to 10 automobiles 66% were distributed contrary to the sanitary clearance regulation and 40% were in the immediate proximity of children's and medical institutions. Such locations of automobile garages near residences must, perforce, affect the sanitary living conditions of the population. The progressive change to ethylated gasoline in city transport imparts to this problem a graver sanitary aspect.

To determine the true nature and extent of the anti-sanitary effects of public garages in the residential areas, a study was made of six residential buildings. Garages housing from 6 to 36 automobiles were parts of 2 of the 6 buildings; in 3 of the six buildings the garages were detached by only 5 to 17 meters from the dwellings, and in one a 30-automobile garage was located as recommended by the sanitary clearance regulation. In addition to the garages, a filling station was located at 18 m from the windows of an apartment house, which was also investigated.

The sanitary investigation and questioning of 110 residents indicated that in nearly all cases the garages occupied a considerable part of the backyard, thereby limiting its use by the residents. The traffic congestion in the backyard presented a constant danger to children's safety. Complaints indicated that a filling station located 18 m from the apartment house windows caused loud noises, and that the exhaust gases penetrated into the apartments and heavily coated the window panes with resinous substance difficult to wash off. Determinations were also made of the presence in the air of CO and of Pb. Car-

bon monoxide determinations were made in the air of garages, near the filling station, in the air of apartments, the windows of which faced the garages and the filling station. For the purpose of comparison studies were made of apartments in the same building, the windows of which were considerably farther away and faced in the opposite direction. A total of 160 analyses were made. To eliminate the possible effect of household gas appliances, the latter were shut off during air sample taking.

The results of carbon monoxide determination in the air of garages, shown in Table 1, indicate that in one third of samples the carbon monoxide concentration was higher than the maximum permissible concentration for workshops, which is 0.03 mg/li. Under the prevailing conditions and in the absence of a systematically organized garage ventilation there was reason to assume that the polluted garage air penetrated into the adjoining apartments. Results of investigations confirmed this assumption. Where garages were located without regard to the 5 - 7 m sanitary clearance from the dwellings, the carbon monoxide concentrations in the apartment air exceeded the 0.06 mg/li single maximum permissible concentration, and the maximum permissible concentration for workshops. In apartments located at the boundary of the recommended sanitary clearance zone the number of samples with high CO concentrations was only 12%.

T A B L E 1.

Carbon monoxide concentration in the air of garages and dwellings.

Place of sample taking	Percent of total number of samples with concns. in mg/li		
	Up to 0.006	Up to 0.030	above 0.030
Garage	40	30	30
Dwellings:			
No sanitary clearance zones	38	41	21
Sanitary clearance zones	50	38	12
Control dwellings	50	42	8

In apartments of the same building with windows considerably farther from the garage and facing in the opposite direction the carbon monoxide concentration of 0.03 mg/li and above was found only in 8% of samples (see Table 1). The effect of a filling station on the indoor air of an apartment house located 18 m away was more pronounced. The filling station serviced up to 700 automobiles within 24 hours. Analytical data in Table 2 indicate that the mean

carbon monoxide concentrations near the gasoline pump and in the apartments located 18 m from it were nearly identical (0.025 and 0.023 mg/li); the mean carbon monoxide concentration in the air of control apartments amounted only to 0.012 mg/li.

T A B L E 2.

Carbon monoxide in mg/li in the air of dwellings and near gasoline pump.

Place of investigation	Carbon monoxide concentration in mg/li		
	Maximal	Minimal	Average
At gasoline pump	0.036	0.018	0.025
In dwellings 18 m from pump	0.042	0.004	0.023
In control dwellings	0.021	0.008	0.012

The greatest number of samples with carbon monoxide concentration above 0.03 mg/li was found near the gasoline pump and in apartments located 18 m from the pump which constituted correspondingly 58 and 18%. No samples with such carbon monoxide concentrations were found in the control apartments. The above data prove that the filling station polluted the indoor residential air, pointing to the urgent need to develop suitable regulatory standards for the width of the sanitary clearance zone between filling stations and dwellings.

A study of the lead oxide content in the air was conducted before the city auto transport changed over to ethylated gasoline; the purpose was to obtain data on the general picture of lead content in the air of garages and of apartments located in the proximity of highways where auto traffic was heavy. For comparison, the air was similarly examined for lead content in the proximity of an arterial highway where motor-traffic was temporarily discontinued. Lead determinations were made by the sedimentation method in a total of 204 air samples. The highest percentage of samples with a lead fall out exceeding 0.1 mg/m² in 24 hours was found among those collected on the busy highway and near a filling station. At those points lead was found in nearly all samples. All samples collected on the highway, where the motor-traffic was temporarily discontinued, were negative.

In evaluating the results obtained, many different factors polluting the city air with lead should be taken into consideration such, for instance, as industrial emissions, printing establishments, repair shops, etc. However, at

the points where the sedimentation samples were collected such sources of air pollution with lead compounds were absent. Based on the considerable amount of lead found in the heavily trafficked highway and near the filling station, and the absence of lead in the air of the "control" highway, it can be assumed that the lead in the air came from moving auto-transport which used ethylated gasoline. The discovery of lead in the air of nearby garages and apartments can be attributed to the repair work done in garages which used lead containing soldering material.

Conclusions.

1. Under the present system of Moscow distribution of residential buildings garages are frequently located in close proximity to dwellings, children's and medical institutions, and the like.

2. Results of laboratory studies and questioning of residents indicated that garages located in residential areas frequently polluted the air to an intensity exceeding the limits of maximum permissible concentrations, thereby vitiating the sanitary living conditions.

3. Heavy air pollution in apartments caused by a nearby filling station indicated the necessity to enforce the regulation that filling stations be located at a prescribed distance from living quarters.

4. Results of the investigation emphasized the inadmissibility of the existence of garages and filling stations directly on residential grounds.

THE SANITARY CLASSIFICATION OF INDUSTRIAL PLANTS AND SANITARY
CLEARANCE ZONES.

(See remarks in foreword).

Chemical Manufacturing Plants.

Class I. Requiring a sanitary clearance zone 2000 m wide.

1. The production of bound nitrogen and of agricultural fertilizers.
2. The production of nitric and other acids, by processes which result in the discharge of oxides of nitrogen into the atmospheric air.
3. The production of ammonia.
4. The production of aniline, nitrobenzol, paranitro aniline, α -naphthol, α , β , and γ , and N-acid, alyzarine and other intermediate products of the aniline dye industry.
5. The production of bromine.
6. The production of paper from sulfite and cellulose sulfate.
7. The production of gases: illuminating, liquid, generator (more than 10 generators with a capacity of 50,000 m³/hr., and plants engaged in the processing of natural refinery gases.
8. The production of sodium hydroxide by the electrolytic process.
9. The production of synthetic viscose fibers and of cellophane.
10. The production of calcium carbide.
11. The production of concentrated mineral fertilizers.
12. The production of volatile oils (solvents) such as benzene, toluol, xylol.
13. The production of medium heavy oils, such as naphthol, phenol, cresol.
14. The production of heavy oils, such as anthracene, phenanthrene, acridine, carbazole.
15. The production of arsenic and its inorganic compounds.
16. The production of gasoline (naphtha-gas) (petroleum gas) in quantities exceeding 5,000 m³/hr.
17. Plants engaged in the processing of crude oils with a sulfur content of over 0.5% and with a high content of volatile carbohydrates.
18. The production of picric acid.
19. The production of hydrofluoric acid and of cryolite.
20. Plants engaged in the processing of coal and of coke.
21. Plants engaged in the processing of shale oil.
22. The production of mercury.

23. The production of soot.
24. The production of sulfuric acid, fuming sulfuric acid and SO_2 gas.
25. The production of carbon bisulfide.
26. The production of organic sulfur dyes such as sulfur black, etc.
27. The production of hydrocyanic acid.
28. The production of synthetic camphor, cellulose esters, etc.
29. The production of hydrochloric acid.
30. The production of superphosphate by plants which have sulfurous acid producing departments.
31. The production of nitrogen containing fertilizers.
32. The production of phosphor, red or yellow.
33. The production of chlorine.
34. The production of chlorinated and hydrochlorinated hydrocarbons in volumes exceeding 1 ton per day.

Class II. Requiring a sanitary clearance zone 1000 m wide.

35. Plants engaged in rubber vulcanization by the hydrogen sulfide method.
36. The production of generator gas from peat coal (medium sized plant, 6 - 10 generators, general production of 25 - 50,000 m^3/hr).
37. The production of natural tars and resins and the processing of tar residues (coal tar pitch, etc.).
38. The production of anhydrous sodium carbonate by the ammonia method in quantities over 400,000 tons per annum.
39. The production of lacquers and varnishes: oil soluble, alcohol soluble, typographical, for use by the rubber industry, insulation material, etc.
40. The production of chromium and lead paints.
41. The production of drying oils and paint vehicles.
42. The production of organic agents.
43. The production of plastic materials from cellulose esters.
44. The production of rare metals by the chlorination method.
45. The production of barium chlorides with the aid of hydrogen sulfide.
46. Plants engaged in the recovery of rubber and caoutchouc.
47. The production of rubber from ebinite.
48. The production of superphosphates without the aid of sulfuric acid and with the aid of fluorides.
49. The production of hydrogenated fat with the aid of non-electrolytically produced hydrogen.
50. The production of factice (rubber substitute from linseed oil).

51. The production of phenol aldehydes and other synthetic resins in excess of 300 tons per annum.
52. The production of fluorides, hydrofluoric acid excepted.
53. The production of synthetic chemical drugs.
54. The production of chlorinated and hydrochlorinated hydrocarbons requiring the use of chlorine up to one ton per day.
55. Plants engaged in the processing of naphtha, containing 0.5% of sulfur and with a low content of volatile carbohydrates.
56. The chemical processing of peat.
57. The production of chromium anhydride and of chromates.
58. The production of electro-insulating lacquers and varnishes and of lacquer and varnish bases in excess of 600 tons per annum.
59. The production of complex ethers and esters.
60. The production of leather substitutes.
61. The synthesis of organic compounds such as alcohols, ethyl ether, etc. from technical and natural gases.

Class III. Requiring a sanitary clearance zone 500 m wide.

62. The production of bitumen and other products from coal tar residue, and residue of naphtha and pine oil (coniferous products).
63. The production of tar and light volatile distillates from wood, methyl alcohol, acetic acid, turpentine, turpentine oil, acetone, creosote.
64. The production of fats by the contact method.
65. The production of anhydrous sodium carbonate by the ammonia method in quantities less than 400,000 tons per annum.
66. The production of caustic soda by the lime and Levit methods.
67. The production of mineral paints other than chromium or lead.
68. The production of mineral salts with the exception of arsenates, fluorides and chromates.
69. The production of naphtha gas in quantities of 1,000 to 5,000 m³/hr; under this heading included generator gas in excess of 10 - 25,000 m³/hr using 3 - 5 generators.
70. The production of nicotine.
71. The production of plastic material, carbolite, celluloid, bakelite, chlorov.
72. The production of compressed and binding materials from paper and fabrics saturated with phenolaldehyde, tars and resins in quantities exceeding 100 tons per annum.
73. The chemical processing of ore of rare metals for the production of salts of antimony, bismuth, lithium, etc.
74. The production of synthetic camphor by the isomerization method.

75. The production of synthetic kaoutchouk or rubber by the alcohol method.
76. The production of fertilizer mixtures.
77. The production of coal products for the electrical industry, such as brushes, electrical carbons, etc.
78. The production of phenol-aldehyde and other synthetic tars and resins not exceeding 300 tons per anum.
79. The production of electroinsulating lacquers and varnishes or lacquer bases not exceeding 500 tons per anum.

Class IV. Requiring a sanitary clearance zone 300 m wide.

80. The manufacture of paper from prepared cellulose and rags.
81. The manufacture of galalith (casein plastic) and other protein plastics, such as aminoplastics and the like.
82. The production of glycerine.
83. The production of generator gas from coal and peat; 1 - 2 generators producing 10,000 m³/hr.
84. The manufacture of synthetic fibers by the acetate and ammonia processes.
85. The manufacture of pencils and crayons.
86. The manufacture of soap on a large scale.
87. The production of natural mineral paints, chalk, ochre, mummy or colco-thar (Persian red), etc.
88. The manufacture of inorganic reagents, manufacture of chlorine and its compounds excepted.
89. The manufacture of organo preparations.
90. The manufacture of pressed and binding materials from paper and fabrics, saturated with phenol-aldehyde tars or resins, not exceeding 100 tons per anum.
91. The production of technical hydrogenated oils resulting in hydrogen liberation non-electrolytically.
92. Plants engaged in salt manufacture by the evaporation and grinding method.
93. The manufacture of pharmaceutical salts of potassium (KCl, K₂SO₄, K₂CO₃, etc.).
94. Match manufacturing.
95. The production of vegetable kaoutchouk or rubber.
96. The production of liquid fertilizers.
97. The production of saccharine and of vaniline.
98. The production of naphtha gas up to 1000 m³/hr.

Class V. Requiring a sanitary clearance zone 100 m wide.

- 99. The production of alkaloids and of galenite preparations.
- 100. The manufacture of paper from waste paper, from prepared cellulose and from rags without bleaching.
- 101. Plants engaged in rubber vulcanization without hydrogen sulfide.
- 102. The manufacture of liquid carbon dioxide and of dry ice.
- 103. The manufacture of synthetic pearls.
- 104. The manufacture of articles from plastic materials by mechanical means.
- 105. The manufacture of perfumes.
- 106. The production of compressed hydrogen and oxygen gases.
- 107. Plants engaged in making photochemical preparations (photoplates or paper).
- 108. The production of carbonate fertilizers.
- 109. The extraction of tannins.
- 110. Areas for the cleaning, washing, and steaming of cisterns or tanks.

Metallurgical, Machine Building and Metallic Processing Industries.

Class I. Requiring a sanitary clearance zone 2000 m wide.

- 111. The production of manganese by the chloride method.
- 112. The secondary processing of non-ferrous metals exceeding 3,000,000 tons per year.
- 113. Coke burning and pig iron smelting by the blast furnace method.
- 114. Smelting non-ferrous metals directly from ore and from concentrates, which includes tin, lead, copper, nickel.
- 115. The production of aluminum by electrolyzing melted aluminum salts.

Class II. Requiring a sanitary clearance zone 1000 m wide.

- 116. Plants engaged in sintering ores of ferrous and non-ferrous metals and/or pyrite cinders.
- 117. The production of non-ferrous metals in excess of 2,000 tons annually.
- 118. The production of manganese by any method, the chloride method excepted.
- 119. Secondary processing of non-ferrous metals not in excess of 1,000 - 3,000 tons annually.
- 120. The reprocessing of pig iron and of steel in quantities exceeding 75,000 tons annually.
- 121. The production of Thomas slag.

- 122. The production of shaped pig iron exceeding 2,000 tons per anum.
- 123. The production of antimony by the pyrometallurgical method up to 300 t./anum.
- 124. The production of zinc, copper, nickel, cobalt by electrolysis of 1 aqueous solution.
- 125. The production of ferro-alloys.

Class III. Requiring a sanitary clearance zone 500 m wide.

- 126. Stations engaged in testing aviation motors provided with sound absorbing facilities to prevent sounds from extending beyond the clearance zones up to 35 decibels.
- 127. Enrichment of metals without heat processing.
- 128. The building of accumulators on a large scale.
- 129. Reprocessing of non-ferrous metals up to 1000 tons annually.
- 130. The production of pig iron and of steel from 10,000 to 75,000 tons annually.
- 131. The production of shaped (cast) pig iron between 5,000 and 20,000 tons per anum.
- 132. The production of non-ferrous metals from 100 to 2000 tons annually.
- 133. The production of lead coated cables.
- 134. The production of rubber insulation.

Class IV. Requiring a sanitary clearance zone 300 m wide.

- 135. The production of non-coated cables.
- 136. The making of boilers.
- 137. The making of machines and equipment for the electric industry, such as dynamos, transformers, projectors, etc. by plants which are equipped with medium sized foundries and other hot manufacturing departments or sections.
- 138. Plants of the metal-processing industry equipped with pig iron, steel (up to 10,000 tons annually) and non-ferrous casting (up to 100 t. annually).
- 139. The production of articles containing mercury, such as mercury rectifiers, thermometers, mercury lamps, etc.
- 140. The production of steel with the aid of electrically operated hearths.
- 141. The production of antimony by the electrolytic method.
- 142. The production of shaped cast pig iron up to 5,000 tons annually.

Class V. Requiring a sanitary clearance zone 100 m wide.

- 143. Plants engaged in metal processing by the heat method not of the foundry nature.

- 144. The building of accumulators on a small scale.
- 145. The manufacture of appliances for the electrotechnical industry, such as electric lamps, etc. not requiring the use of foundries.
- 146. The production of resistant (hard) alloys and metals of high melting point by methods other than chemical processing of the ores.

Mining and Other Natural Mineral Resources.

Class I. Requiring a sanitary clearance zone 2000 m wide.

- 147. Production of crude oil with a sulfur content exceeding 0.5% or having a high content of volatile hydrocarbons.

Class II. Requiring a sanitary clearance zone 1000 m wide.

- 148. Production of shale fuels (oils).
- 149. Mining of coal, anthracite, brown coal, etc.
- 150. Mining iron ore by the open explosion method.
- 151. Production of phosphorites, apatites, colchedans by non-chemical methods.
- 152. Production of lead ores, and of arsenic and manganese by the smelting, sintering or enrichment methods.

Class III. Requiring a sanitary clearance zone 500 m wide.

- 153. Production of crude oil having a sulfur content below 0.5% and also having a low content of volatile hydrocarbons.
- 154. Production of dolomites, magnesites, asbestos, petroleum asphalt, etc.
- 155. Rock production by the explosion method.
- 156. Production of metal ores and of metalloids by the open method, lead, arsenic and manganese ores excepted.
- 157. The production of bricketts from fine coal and coal dust.
- 158. The production of peat bricketts.

Class IV. Requiring a sanitary clearance zone 300 m wide.

- 159. Production of metal ores and of metalloids by the mining method; lead ores, arsenic and manganese excepted.
- 160. Production of peat by the milling cutter method.
- 161. The production of rock salt (NaCl).

Plants of the Building Industry.

Class I. Requiring a sanitary clearance zone 2000 m wide.

- 162. The production of portland cement, slag-portland cement and of puzuolanic cement; over 150,000 tons per anum.

Class II. Requiring a sanitary clearance zone 1000 m wide.

- 163. The production of portland cement, slag-portland cement and puzolanic cement up to 150,000 tons annually.
- 164. The production of lime, magnesite and dolomite by the burning methods within the mines or in ground-type furnaces.

Class III. Requiring a sanitary clearance zone 500 m wide.

- 165. The production of local cements up to 5,000 tons annually.
- 166. The production of alabaster.
- 167. The production of concrete asphalt.
- 168. The production of glass wool and slag wool.
- 169. The production of tar paper.
- 170. The production of "Rubberoid".

Class IV. Requiring a sanitary clearance zone 300 m wide.

- 171. The production of asbestos cement and of slate.
- 172. The production of artificial stones and concrete-made objects.
- 173. Stone casting.
- 174. The manufacture of red and yellow bricks.
- 175. The manufacture of cinder blocks and ceramics and other heat resistant items.
- 176. Glass making.
- 177. The manufacture of porcelain, glazed and clay items.
- 178. Cement elevators and other dust creating construction materials.

Class V. Requiring a sanitary clearance zone 100 m wide.

- 179. Rock production by non-explosive methods and the processing of natural rocks.
- 180. The manufacture of gypsum items.
- 181. The manufacture of reed press-boards, and other similar press-boards.
- 182. The manufacture of construction materials from electric power station waste products.

Plants of the Wood Processing Industries.

Class I. Requiring a sanitary clearance zone 2000 m wide.

- 183. The manufacture of charcoal.

No class II requiring a sanitary clearance zone 1000 m wide is included here.

Class III. Requiring a sanitary clearance zone 500 m wide.

184. Plants engaged in the treatment of wood by processes of infiltration of oil or bitumenous products (wood preservation).

Class IV. Requiring a sanitary clearance zone 300 m wide.

185. The production of wood fibers.
186. The production of charcoal by the retort method.
187. Sawmills, the production of ply-wood and of standard house parts.
188. Shipbuilding wharves (for the building of large wooden ships).
189. The production of items for the transport industry.

Class V. Requiring a sanitary clearance zone 100 m wide.

190. The manufacture of articles from wood fibers.
191. Bast fiber rug weaving.
192. Joiner and carpenter shops for the manufacture of furniture, parquet floors, boxes, etc.
193. The manufacture of barrels from ready-made staves.
194. Plants engaged in the conservation-processing of wood by aqueous solutions and other preservative preparations free from salts of arsenic.
195. Wharves for the building of small ships or similar vessels.

Textile Manufacturing.

Class I. Requiring a sanitary clearance zone 2000 m wide.

196. Plants engaged in the chemical impregnation and other processing of textile fabrics with hydrogen sulfide.

Class II. Requiring a sanitary clearance zone 1000 m wide.

197. Plants continuously engaged in the impregnation of textile fabrics and/or paper with oil-asphalt combination, bakelite and other lacquers or varnishes for use by the electric industry with an annual production volume of impregnated materials of 300,000 tons.
198. Plants engaged in the primary processing of vegetable fibers such as flax, linen, cotton and indian hemp.

Class III. Requiring a sanitary clearance zone 500 m wide.

199. Plants continuously engaged in the impregnation of fabrics and of paper with oils, oil-asphalt combinations, bakelite and other lacquers with an annual production up to 300 tons of impregnated material.
200. The impregnation and other processing of fabrics with chemical substances, such as dermatin, granitol, etc., but not with hydrogen sulfide.

Class IV. Requiring a sanitary clearance zone 300 m wide.

- 201. Cotton processing plants.
- 202. Cocoon boiling plants.
- 203. Synthetic wool rug weaving.
- 204. Rope and twine making.
- 205. Melange plants.
- 206. Bleaching plants, dyeing and finishing plants.
- 207. The manufacture of yarn and fabrics from cotton, linen, wool by plants equipped with bleaching and dyeing facilities.

Class V. Requiring a sanitary clearance zone 100 m wide.

- 208. The manufacture of yarn and fabrics by plants having no bleaching and dyeing installations.
- 209. Plants engaged in making knit goods and lace material.

Industries Engaged in the Processing of Products of Animal Origin.

Class I. Requiring a sanitary clearance zone 2000 m wide.

- 210. Plants which make glue from remnants of hides, bones and other animal discards.
- 211. Plants engaged in making bone charcoal and bone meal.
- 212. The manufacture of technical gelatin from the usual parts of animal discards kept in the open air.
- 213. Utilization plants for the processing of suet, dead animals, fish, and similar material for the conversion into fat, animal feed and fertilizer, etc.

Class II. Requiring a sanitary clearance zone 1000 m wide.

- 214. Plants engaged in the processing and dyeing of furs of large animals.

Class III. Requiring a sanitary clearance zone 500 m wide.

- 215. The production of animal feed from food leftovers in the food-processing combines.
- 216. Plants engaged in the processing and dyeing of raw furs and hides of small animals.
- 217. The processing of hides of large animals by the tannin methods, such as the production of soft leather, shoe upper leather, sole leather, etc.
- 218. Wool cleaning and washing.
- 219. Fat or suet melting for the production of technical fat and suet over 30,000 tons per annum.

220. Storehouses for salted wet raw hides with a capacity of over 200 hides.

Class IV. Requiring a sanitary clearance zone 300 m wide.

221. Fulling and felt manufacturing.
222. The production of gelatin of higher purity from fresh, clean bones of short storage in refrigerated rooms.
223. The manufacture of artificial leather.
224. Technical fat and suet melting, up to 30,000 tons annually.
225. The preparation of skeletons and other educational visual material from animal carcasses.
226. The processing of hair, fur, down, feathers, horns and hoofs.

Class V. Requiring a sanitary clearance zone 100 m wide.

227. The manufacture of foot wear; small individually owned and cooperatives excepted.
228. The manufacture of high-polished (lacquered) hides (leather).
229. The manufacture of travel bags and suitcases; small cooperatives excepted.
230. The manufacture of bone articles; small cooperatives excepted.
231. The manufacture of brushes from hair and bristle.
232. Felt production.
233. Storage houses holding 200 wet salted hides, raw, on a temporary basis.
234. The manufacture of musical strings and cat-gut from animal intestines.

Food Products Processing and Spice Manufacturing Industries.

Class I. Requiring a sanitary clearance zone 2000 m wide.

235. Animal corrals holding over 3,000 heads.

Class II. Requiring a sanitary clearance zone 1000 m wide.

236. Slaughter houses.
237. Animal corrals holding 300 - 3,000 heads.
238. Rendering sea animal fat.
239. Cleaning and processing of intestines.
240. The manufacture of beet sugar.
241. Centers for sweeping and washing of freight cars used in animal transportation.

Class III. Requiring a sanitary clearance zone 500 m wide.

- 242. Abattoirs with a capacity for 300 heads.
- 243. Production of albumin.
- 244. Production of dextrine, glucose and sugar syrup.
- 245. Production of starch in potato-grinding plants.
- 246. Rabbit meat processing.
- 247. Fowl slaughtering.
- 248. Fish industry plants.

Class IV. Requiring a sanitary clearance zone 300 m wide.

- 249. Alcohol distilling plants.
- 250. Flour mills, hulling mills.
- 251. Meat combines.
- 252. Coffee roasting plants.
- 253. Oil producing mills.
- 254. Production of margarine and oleomargarine.
- 255. The processing of vegetables such as preserving, drying, pickling, etc.
- 256. Cheese making.
- 257. Fish combines, fish preservation and other processing.
- 258. Plants of the tobacco and makhorka (Nictiana rustica) industry.

Class V. Requiring a sanitary clearance zone 100 m wide.

- 259. Beer breweries and allied processes.
- 260. Conservation factories.
- 261. Liqueur and other alcoholic beverage distilleries.
- 262. Vegetable storehouses.
- 263. Sugar refineries.
- 264. Fish-smoking shops.
- 265. Macaroni manufacturing.
- 266. Dairies.
- 267. Bologna and sausage manufacturing.
- 268. Fancy bakeries.
- 269. Bakeries, large scale.
- 270. Prepared food manufacturing.
- 271. Production of food spices.
- 272. Refrigerators, large, commercial.

SUPPLEMENT OR APPENDIX 4, PP. 130-131.

Limits of Allowable Concentrations of Harmful Gases, Vapors and Dust in the
Air of Industrial Production and Manufacturing Premises.

Name of the substance	The limits of allowable concentration in mg/li
Acrolein - - - - -	0.002
Ammonia - - - - -	0.02
Acetone - - - - -	0.2
Aniline, toluidine, xylidine - - - - -	0.005
Benzidine, dianizidine, alpha- and beta-naphthylamine	0.001
Benzene, white-spirit, ligroine, kerosene, mineral oils - - - - -	0.3
Benzole (benzene) - - - - -	0.1
Divinile, pseudobutylene - - - - -	0.1
Di- and trinitrocompounds of benzene and its homo- logues (dinitrobenzene, trinitrotoluol) and other	0.001
Manganese and its compounds - - - - -	0.0003
Arsenious acid - - - - -	0.0003
Arsenic and its compounds, calculated as As - - - - -	0.0003
Unsaturated fatty alcohols (allyl, etc.) - - - - -	0.002
Nitro- and dinitrochlorobenzene compounds (nitro- chlorobenzenes, dinitrochlorobenzenes, etc.) - - -	0.001
Nitrobenzene compounds and its homologues (nitro- benzene, nitrotoluol, etc.) - - - - -	0.005
Oxides of nitrogen as N ₂ O ₅ - - - - -	0.005
Ethylene oxide - - - - -	0.001
Zinc oxide - - - - -	0.005
Carbon dioxide - - - - -	0.01 (1)
Metallic mercury - - - - -	0.00001
Lead and its inorganic compounds - - - - -	0.00001
Sulfuric acid and fuming sulfuric acid - - - - -	0.002
Sulfur dioxide - - - - -	0.02 (2)
Hydrogen sulfide - - - - -	0.01
Carbon bisulfide - - - - -	0.01
Turpentine - - - - -	0.3
Butyl alcohol - - - - -	0.2
Methyl alcohol - - - - -	0.05
Ethyl alcohol - - - - -	1.0
Mercuric chloride - - - - -	0.0001
Tobacco and tea leaf dust - - - - -	0.003
Toluol, xylol and solvent naphtha I and II - - - - -	0.1
Phenol - - - - -	0.005
Formaldehyde - - - - -	0.005
Carbonyl chloride - - - - -	0.0005
Phosphorus yellow - - - - -	0.00003
Hydrogen phosphide - - - - -	0.0003
Hydrofluoric acid and fluorides - - - - -	0.001
Chlorobenzene - - - - -	0.05

Chlorinated hydrocarbons:

dichlorethane - - - - -	0.05
trichlorethane - - - - -	0.05
chloroprene - - - - -	0.002
HCl gas and HCl acid - - - - -	0.01
Chromic anhydride, chromates and dichromates - - - - -	0.0001
Chloronaphthalene and chlorodiphenyl - - - - -	0.001
Chlorine - - - - -	0.001
Hydrocyanic acid - - - - -	0.0003
Carbon tetrachloride - - - - -	0.05
Ethyl ether - - - - -	0.3

Esters of acetic acid (acetates):

Amyl acetate - - - - -	0.1
Butyl acetate - - - - -	0.2
Methyl acetate - - - - -	0.1
Propyl acetate - - - - -	0.2
Ethyl acetate - - - - -	0.2

(1) In the blast furnace and open hearth furnace departments, in foundries, in gas-generating departments and in general production where carbon dioxide appears as a raw product (ammonia synthesis) the limit of its allowable concentration is to be 0.03 mg/li.

Where work in gas-polluted atmosphere does not extend beyond one hour, the limit of allowable concentration of carbon dioxide may be raised to 0.05 mg/li; if not longer than 30 minutes to 0.2 mg/li. Repeat exposure shall be permitted, provided intermittent rest intervals of not less than 2 hours are instituted.

In garages servicing automobiles the limit of allowable concentration of carbon monoxide should be based on the hourly average; where exposures do not exceed 15 minutes the allowable limit of carbon monoxide concentration can be raised to 0.12 mg/li.

(2) In the vicinity of smelting and burning substances containing sulfur the limit of allowable concentration shall be 0.04 mg/li.

Effectiveness of Sanitary Clearance Zones Between Industrial Enterprises and Residential Quarters.

D. N. Kalyushnyi, Ya. I. Kostovetskii, S. A. Davydov and M. B. Aksel'rod.

Ukrainian Institute of Community Hygiene.

Gigiena i Sanitariya No. 4, 1952, pp. 9-12.

Plant life capable of retaining dust, smoke and gases constitute a necessary and basic element of sanitary clearance zones separating industrial enterprises from residential quarters. At the end of the 19th century K. N. Vakulovskii noted that "factory soot affected not only people but also plant life which normally protected people from the deleterious effect of the soot. It is desirable, therefore, that wide green clearance zones (green belts) surround factories and industrial enterprises especially in the presence of residential areas". (K. N. Vakulovskii. "The Importance of Plants to Health in General and for City Dwellers in Particular". St. Petersburg, 1898.)

In recent years Soviet scientists studied the protective effects of green clearance zones. During her studies of sulfur and suspended matter in the air Z. N. Kulichkova noted that plant life in parks possessed the capacity to retain dust and absorb gases. She showed that when the trees were covered with leaves the air of green clearance zones and of parks contained 24.2% less of sulfur and 21% less of suspended matter, than did the air of the nearby streets. A. N. Marseev also demonstrated the capacity of ligneous plants to retain dust and discussed the mechanism by which trees freed the air from dust. V. A. Yakovenko was the first to correlate the width of green sanitary clearance zones with their capacity to remove pollution from atmospheric air; in determining the width of green sanitary zones he took into consideration such factors as temperature inversions, velocity of air currents, height at which wastes were discharged, etc. V. A. Yakovenko and D. N. Kalyushnyi studied the purifying effect of green parks in the air of Khar'kov; they demonstrated that the city's green parks had a noteworthy dust-clearing effect in the summer as well as in the winter. Analogous studies were made by A. A. Adamova who established that the air purifying capacity of green sanitary clearance zones applied to smoke as well as to dust. V. A. Uglov found that the air of groves contained lower concentrations of soot than the air of neighboring open spaces even when the trees were devoid of leaves. V. K. Fedinskii, Ts. P. Kruglikova and G. V.

Dyshko demonstrated the capacity of planted areas to retain cement dust. A. A. Adamova and A. G. Ionina established the sanitary significance of trees which bordered city streets. M. S. Goldberg and V. F. Docuchaieva studied the dust clearing property of green sanitary clearance zones. P. A. Babayants reported on the considerable damage caused to such trees as the birch, linden, larch, ash and oak by chemical plants 2.5 km away. A. P. Krasinskiy investigated the harmful effects of gases on vegetation and the capacity of the latter to purify air.

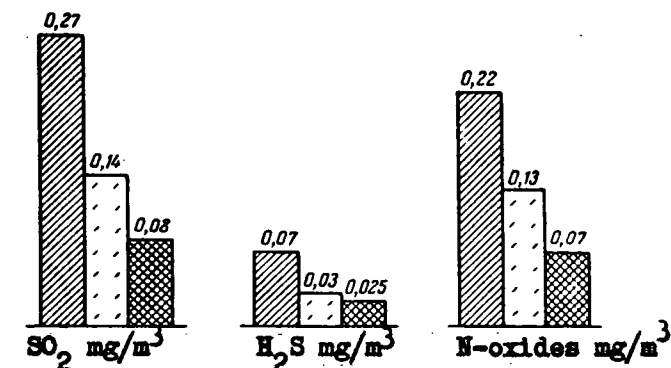
The authors of this report attempted to make a more thorough study of the protective effect of green sanitary clearance zones between industrial plants and residential areas. A study was made of sanitary clearance zones of two large industrial centers of the Ukrainian U. S. S. R. In one town, the investigation was made in June of 1950 in the vicinity of large ferro-metallurgical plants. A green clearance zone was located south of the factory grounds between the production plants and the temporary settlements extending V-shaped from 30 m to 500 m from east to west. This sanitary clearance zone was about 20 years old and the trees consisted chiefly of leafy species such as acacia, maple, etc., spaced 0.5 - 0.7 m apart. No visible indications were seen of smoke and gas damage to the foliage. Studies were also made at the widest part of the green sanitary clearance belt situated between another settlement and a metallurgical combine with particular reference to air-polluting substances of hygienic importance, such as sulfur dioxide, hydrogen sulfide, etc. Samples were collected by aspiration. Sulfur dioxide was determined by the usual nephelometric method and hydrogen sulfide by Polezhayev's colorimetric method.

To determine the air purifying effect of the green sanitary clearance zones samples were collected on either side of the clearance zone at the same time as air control samples were collected at similar distances from the plants where sanitary clearance zones were absent. Air samples totaled 32. During the investigation the weather was dry, hot and sunny; air temperature at times rose to 30°. Wind velocity varied between 1 - 4 m/sec. In the accompanying Figure averages are presented showing the decrease in concentrations of sulfur dioxide, hydrogen sulfide and of nitric oxide at distances of 1,000 - 1,500 m from the factories, depending on the sanitary clearance zone type of plant life. The data indicated that concentration of air polluting substances decreased with the distance from the factories as a result of the air purifying effect of the

sanitary clearance zones. Averages showed that the concentration of sulfur dioxide outside the green strip, at a distance of 500 m, fell from 0.27 to 0.14 mg/m³ or, approximately 50%, and inside the green strip it fell from 0.27 to 0.08 mg/m³, or approximately 33.3%. The same was observed for hydrogen sulfide. If the content of sulfur dioxide and of hydrogen sulfide present in the air outside the sanitary clearance zones is taken as 100% then the amount of sulfuric compounds taken at 500 m from the initial point fell to 51.8 - 42.8% in the sanitary clearance zone still free from plant life, and to 15.7 - 29.6% in the green (fully developed) sanitary clearance zones. Thus the results showed that the decrease in atmospheric air pollution by sulfur dioxide and by hydrogen sulfide was the result not only of distance from the industrial discharge, but also plant life capacity to retain air pollution. Tests were also made of air samples taken at five fixed points for the determination of dust concentration, one of the air sampling points was located beyond the green sanitary clearance zone; another point was at equal distance from the source of pollution, but had no intervening green belt. In interpreting the results of analyses of the air samples collected at these two points due consideration was given to frequency of wind blowing from the plants in the direction of each of the air collection points.

Air collected at the fixed points was analyzed daily over a period of 5 months using the sedimentation method of the Ukrainian Institute of Communal Hygiene. For control purposes air samples were collected from time to time on the lee side of the same fixed points. The atmospheric air dust concentration was considerably lower at the second collection point than at the first even though the first was farther removed from the factory than the second. Dust sedimentation at the first point averaged 1,536.8 mg/m² per 24 hours and at the second 1,004 mg. This was in agreement with the results of parallel aspiration tests which were correspondingly 1.25 mg/m³, and 0.58 mg/m³. Results of all tests clearly pointed to the fact that plants of the green sanitary clearance zones investigated absorbed dust and gases from polluted air.

In the fall of 1950 a study was made of the effectiveness of green sanitary clearance zones in another town which had a nitrogen fertilizer factory. A 500 m wide green sanitary clearance zone was located on one side of this factory at a distance of 1 km. Its plant life consisted of leafy trees of different species; the trees were 10 - 12 m high and spaced 0.7 - 0.8 m apart; there



Initial point

500 m from initial point, no sanit. clear. zone

500 m from initial point, sanitary clearance zone

Reduction in concentrations of sulfur dioxide, hydrogen sulfide and oxides of nitrogen in relation to green sanitary clearance zones

14° and wind velocity varying from 0.5 to 3.5 m/sec. Air samples were collected on both sides of the green sanitary clearance zone; control samples were collected at same distances in an area which had no intervening green belt. It can be seen from the schematic drawing that nitric oxide was absorbed from the air by the green sanitary clearance zone.

Air samples collected at 1000 m from the factory contained approximately equal concentrations of nitric oxide (0.23 and 0.22 mg/m³); the picture markedly changed at 1,500 m from the production plant; in the absence of intervening green belts nitric oxide fell to 0.13 mg/m³ and in the presence of green sanitary protection zones it fell to 0.07 mg/m³. If the concentration of nitric oxide in atmospheric air in the vicinity of the fertilizer plant, i.e., before passing over the green sanitary clearance zone be denoted as 100%, then the concentration of nitric oxide at 500 m from the initial point was reduced to approximately 50%, due to distance dispersion alone. At a similar distance and after having passed over the green sanitary clearance zone the nitric oxide concentration was reduced to 33%.

Subjective data obtained by questioning the inhabitants also pointed to the beneficial air purifying function of green sanitary clearance zones.

Summary.

Results of atmospheric air studies in the vicinity of chemical and metallurgical plants demonstrated that dust, sulfur dioxide, hydrogen sulfide and

were no signs of visible damage. New residential buildings were erected on the other side of the green strip. Air samples were collected by the aspiration method. Nitric oxide was absorbed twice by distilled water and determined by the Griss reagent. A total of 51 air samples were collected in cool and damp weather at temperatures of 7 -

nitric oxide were absorbed from polluted air by suitable types of plant life to a considerable degree. It is recommended that in creating intervening sanitary clearance zones provisions should be made at the same time for planting in such zones suitable trees and other types of plant life.

Planning and Effecting Sanitary Clearance Zones in the Ukraine.

By

D. N. Kalyuzhnyi and Ya. I. Kostovetskii.

From the Ukraine Institute of Community Sanitation.

Gigiena i Sanitariya, No. 7, 9-12, 1952.

The creation of sanitary clearance zones between industrial establishments and residential sections at the time when plans are made for the building of new towns is a notable accomplishment of the Soviet hygiene and practical sanitation. This measure for the protection of atmospheric air of residential sections against pollution with industrial emissions has been widely used in the reconstruction of old and building of new towns and workers' settlements.

Twenty-five years have passed since regulations for the establishment of clearance zones between industrial establishments and residential sections were first incorporated into the Soviet law and the measure was put into practice. Improvements in means and methods for the abatement of deleterious by-products and advances in the general technology of industrial production brought about considerable purification of industrial emissions and made possible the reduction of the width of sanitary clearance zones. "Sanitary Norms for Proposed Industrial Production Plants", published in 1951 (NSP-101-51) required that plans for new industrial plants include provisions for the installation of dust abating and gas purifying equipment, elimination of gas leaks, recovery of waste products, etc. "Sanitary Standards" (NSP-101-51) stipulate that when the abatement of harmful effects of industrial by-products on the population was technically impossible, the State Sanitary Inspector may demand enlargement

of the existing sanitary clearance zone to not more than twice the prescribed width. Where efficient measures for eliminating industrial by-products are in effect, the sanitary clearance zones may be decreased in size. Such flexibility of the law is of particular value since, on the one hand, it empowers the State Sanitary Inspector to decrease the size of the clearance zones, depending upon local conditions, while, on the other hand, it encourages industrial establishments to develop and install more efficient equipment to minimize industrial air pollution by emissions. Production executives are interested in decreasing the size of the sanitary clearance zones.

Such an approach to the problem of purifying the atmospheric air of industrial towns is progressive, technically feasible and promotes good sanitation. To this end, as early as 1949, Prof. T. Ye. Boldyrev wrote: "We are entering a period when all the problems (size of sanitary clearance zone) related to a particular industrial enterprise may be solved for each individual case by making use of most recent findings in the field of hygiene". (*Gigiena i Sanitariya*, No. 1, 1949).

Industrial ministries manifested a more favorable attitude toward the problem of air purification. This change in attitude is reflected in the greater cooperation between the State Sanitary Inspector and production authorities. However, it does not mean that sanitary clearance, as a means of reducing the harmful effects of industrial emissions on the sanitary living conditions and on the health of the population, are losing their importance. Together with effective sanitary measures applied by production industries sanitary clearance zones remain a factor of great importance not only in respect to reduction of air pollution, but also in respect to noise, traffic, soil pollution, etc. With respect to these effects, the twenty-five years' experience in the planning and practice of sanitary clearance zones is of scientific and practical importance.

The study herein reported was organized by the Ukrainian Institute of Community Hygiene. Examination revealed that the sanitary clearance zones surrounding industrial establishments, in the majority of cases, were planted with trees, shrubs and bushes which protected the population from the deleterious effects of industrial discharges. Such beneficial aspects were particularly in evidence in Khar'kov, Zaporozh'e, Dnepropetrovsk, Krivoi Rog and other cities. The sanitary clearance zones in the vicinities mentioned were instituted and trees and shrubs planted at the time the industrial establishments were being

built. This separated the production and processing industries from the residential sections by wide green belts landscaped with trees of 15 - 20 m high. The trees were principally acacia and maple which thrive in the climatic conditions of the Ukraine even in strongly polluted air. Special analyses of the air and interrogation of the population in the areas of the industrial plants established that the sanitary clearance zones constituted a fairly efficient protection from dust and gases. It is regrettable that the sanitary clearance zones have been developed only on one side of the industries mentioned. Among the industries investigated were the ferrous metallurgy, the chemical industry and power plants; here the sanitary clearance zones were not wide enough and the trees and shrubs were planted in an unplanned manner. The sanitary clearance zones were of particular benefit to miners' settlements, since such zones were the only effective means of abating or eliminating the injurious effects of air pollution from burning waste dumps. Sixty-nine of the 136 mines surveyed in the Stalinskaya and Voroshilovgradskaya regions had burning waste dumps of which 16 were burning intensely and 53 moderately. In 50% of the surveyed mines the burning waste dumps produced sulfur dioxide, which polluted the air within a radius of 500 - 1,000 m; this once more pointed to the necessity for strict adherence to the provisions of the "Sanitary Standards" related to sanitary clearance zones surrounding mines.

Up to the year 1930 miners' settlements were built in close proximity to the mines. Soviet sanitary legislation regulating the planning of residential centers was enacted early in 1930, and the haphazard construction of homes in the immediate proximity of mines was prohibited; approved housing projects were instituted. Of 59 workers' settlements erected in Donbass during 1931 - 1948, 52 were built according to approved plans. But even here the space breaks were not of sufficient width everywhere, nor were they properly landscaped. However, the mere fact that nearly all miners' settlements built during the last 20 years were provided with sanitary clearance zones should be considered as an accomplishment in Soviet sanitation and Soviet building regulations.

Despite the fact that benefits of sanitary clearance zones are questioned by no one, the manner in which they were instituted until now showed serious shortcomings. To begin with, not always has sufficient consideration been given to the creation of necessary sanitary clearance zones around production plants which unfavorably affected the surrounding populations. This explains why some settlements built between 1931 and 1948 had sanitary clearance zones only up to 500 m wide, which is narrower than that stipulated in the last sanitary regulations for the planning of industrial enterprises. The planting of trees, shrubs and

bushes within the sanitary clearance zones was too sparse in many cases. Clearance zones, as a rule, were not instituted at the time of construction of the industrial plants and of the houses of a settlement or town. Opening of the operation of an industrial plant did not call for an inspection certificate relative to the sanitary clearance zones, as was required in cases of other industrial and residential community constructions. The proper protection of the health of the population urgently demands that building and construction organizations, industrial authorities and community leaders be made more strictly responsible for the effectuation of the right type of sanitary clearance zones. Temporary settlements have sprung up inside sanitary clearance zones on frequent occasions. Such "temporary" settlements, and especially those having particularly bad sanitation conditions must be abolished.

Serious derelictions were discovered in the Ukraine during the post-war period; a study was made of towns and workers' settlements prepared by two large planning organizations in the Ukraine. This study embraced 54 plans which included 29 plans for miners' settlements. The most striking observation was related to the utter lack of uniformity and proper system in planning sanitary clearance zones. Only 25 plans, the majority of which were for miners' settlements, had properly developed plans for the sanitary clearance zones which were included in the specifications and blueprints of the projects. In another group of ten projects the sanitary clearance zones were mentioned only in the explanatory notes, but did not appear in the blueprints. In another group of projects the sanitary clearance zones were mentioned only casually without reference to their dimensions and locations. Finally, in several cases where the area of the project had no sources of intense air pollution the sanitary clearance zones were not mentioned at all. In some instances the instructions for the planting of trees and shrubs were rather vague.

Establishing sanitary clearance zones is an important sanitary measure; they should be appropriately developed by planning organizations, while agencies of the State Sanitary Inspection should enforce the realization of such plans. If sanitary clearance zones are not clearly outlined, or are omitted in the plans of a settlement, the possibility for their being created during the construction of the settlement will be very remote, if at all. The architects and builders should plan for the best type of the sanitary clearance zones with regards to planting fruit trees, berries, shrubs, vegetable gardens, decorative plants, water reservoirs, etc. Only thus will sanitary clearance zones between residential sections and the sources of air pollution become economically sound.

Sanitary Clearance Zones between Residential Sections and Places of Fuel Storage in Sovkhozes of Saratovsk (Oblast) Territory.

V. A. Kononova.

Saratovsk Institute of Hygiene and Occupational Pathology.

Gigiena i Sanitariya, 23, No. 6, 1958, pp. 11-14.

The spread and development of new sovkhozes in the Saratov Volga Region confronted us with the responsibility of making sanitary surveys and of presenting plans and sanitary recommendations essential to the well-being of future residents. In such instances the point of primary importance was the rational separation of future settlements into residential and industrial or commercial sections. Existing sanitary regulations prescribe the width of sanitary clearance zones which must be instituted between residential constructions and sections of commercial or industrial character. It must be stated in this connection that such regulations are based on inadequate sanitary scientific foundations.

The mechanization of agriculture is constantly growing paralleled by an extension of centers where automotive agricultural machinery is housed for distribution. Such centers also store the fuel required for the operation of agricultural automotive machines. For this reason the presently prescribed 75 m wide sanitary clearance zone between residential sections and places of fuel storage should be reexamined scientifically and more thoroughly. The presently wide-spread and continually increasing use of ethylated gasoline adds to the need for such a reexamination, since this fuel can become a cause of animal and human intoxication under certain conditions. The reexamination extended over seven sovkhozes of the Saratovsk Volga Oblast. Determinations were made for the presence of tetraethyl lead in the air and soil at different distances from the storage tanks; in addition determinations were made for the presence of hydrocarbon vapors in the air of two sovkhozes and of tarry substances in 4 sovkhozes. Air and soil samples were collected at 25, 50, 75, 100 m from the gasoline storage tanks in the direction of winds blowing from the points of tank location. The fuel storage tanks were located 70 - 300 m from the sovkhozes under study in areas specially designated for this purpose in the industrial sections. All auto-transportation and agricultural machines of the sovkhozes under study were run by tetraeth-

yl gasoline. Gasoline tanks and tanks containing the different oil and grease materials were located in rows close to the ground, supported when required by suitable reinforcements; some were kept in excavated pits.

In only three sovkhoses - Krasnyanskii, Komsomol'skii and Dekabrist - was the method of rubber hose gasoline delivery directly into the tanks of motors in use. In the remaining four sovkhoses the gasoline was poured into the motor tanks by hand which resulted in much of the gasoline being splashed near the storage tanks, and the soil was saturated in spots with gasoline and lubrication material. The motor fuel supply center at sovkhos Dekabrist serviced motor vehicles of the sovkhos and of the nearby railroad system with a total of close to 100 automachines. The other six sovkhos supply centers serviced between 40 to 60 motor machines each. Concentrations in mg/m^3 of tetraethyl lead found in the atmospheric air are shown in Table 1.

Table 1.
Tetraethyl-lead in mg/m^3 in atmospheric air at different distances from gasoline storage tanks in sovkhoses.

Sovkhos	Meters from storage tank					Wind vel. in m	Time of year
	At tank	25	50	75	100		
Im. Radishcheva..	0,0218	0	0	0	0	5,5	Spring
"Zernovoi!".....	0	0	0	0	0	9,9-10,9	"
"Urozhainyi"	0	0,249	0,0249	0	0	9,1-11,9	Summer
"Komsomol'skii" ..	0,0234	0	0	0	0	3,1-3,6	Fall
"Dekabrist".....	0,0218	0,0218	0	0	0	5,0-0,7	"
"Dergachevskii" ..	0,0234	0,0265	0,0234	0	0	2,5-5,1	"
"Dergachevskii" ..	0,0218	0,0160	0	0	0	5,0	"

Data presented in Table 1 show that tetraethyl lead was present in the air 25 - 50 m from the storage tanks, and that wind velocity was a determining factor of the concentration found in the air. This was clearly indicated by the fact that no tetraethyl lead was found in the air of sovkhos Zernovoi at any distance from the distributing tank when the wind velocity was 9.9 - 10.9 m/sec. At the time the air sample was collected at the storage tank of sovkhos Urozhainyi the wind velocity was 9.1 m/sec. and, as can

be seen from Table 1, the sample of air was free from tetraethyl lead due to its rapid dispersion by the wind current. The time of the year did not appear to have any effect on the tetraethyl lead concentration in the atmospheric air, probably due to the high volatility of tetraethyl lead. A. B. Reznikov pointed out that the volatility of tetraethyl lead was high even at temperatures below zero. In our case no atmospheric temperatures below zero were encountered during the fall of the year.

Data pertaining to soil tetraethyl lead content are presented in Table 2. Tetraethyl lead was found in all soil samples taken at the storage tanks; at a distance of 25 m from the storage tanks some soil samples gave negative tetraethyl lead tests; at a distance of 50 m from the storage tank the number of negative soil samples considerably increased.

T a b l e 2 .

Tetraethyl-lead in mg% in soil at different distances
from gasoline storage tanks in sovkhoses.

Sovkhoz	Meters from gasoline storage tank				
	At tank	25	50	75	100
Im. Rodishcheva .	0,0602	0	0,0164	0	0
"Zernovoi"	0,0123				
	0	0	0	0	0
"Urozhaiyi" . . .	0,014016	0,00246	0	0	0
	0,00257				
"Komsomol'skii" .	0,00246	0	0	0	
	0,0161				
"Krasnyanskii" . .	0,0123	0,00246	0	0	0
"Dekabrist"	0	0,039	0	0	0
"Dergachevskii" .	0,0601	0	0	0	0

All soil samples were collected at locations which were free from visible discoloration; it can be assumed, therefore, that in the case of positive samples tetraethyl lead found its way into the soil through the process of adsorption. It is known that vapors of tetraethyl lead are 11.2 times as heavy as air and that they are easily adsorbed by soil and other porous substances (according to I. Ya. Sosnovik). It can be seen from Table 2 that the soil at the storage tank of sovkhos Dekabrist was negative for tetraethyl lead. In explanation of that it should be stated that the ground at that storage tank was sloping away and that soil samples were collected shortly after a heavy beating rain.

Data related to hydrocarbon content in the atmospheric air are presented in Table 3.

T a b l e 3 .

Hydrocarbons in atmospheric air at different distances from gasoline storage tanks in sovkhoses (in mg/l).

Sovkhoz	Meters from gasoline storage tank					Wind vel. in m
	At tank	25	50	75	100	
"Dekabrist" . .	0,19	0,27	Sample lost.	0,31	0,24	Calm -4
"Dergachevskii"	0,15	0,34	0,34	0,1	0,12	5-7,5

Data presented in Table 3 show that at distances of 25 and 50 m from the gasoline storage tank of sovkhos Dergachevskii and 75 m from the storage tank of sovkhos Dekabrist the concentration of hydrocarbons in the atmospheric air exceeded the limit concentration allowable for air of industrial work premises.

The data presented in Table 3 show that the concentration of hydrocarbons in the atmospheric air of the fuel supply centers of sovkhoses Dekabrist and Dergachevskii was greater at 25 - 50 m and in one instance at 75 m than it was at the supply tank and at 100 m. This seemingly paradoxical condition can be explained by the fact that at distances between 5 - 50 m there usually was a congregation of motor vehicles coming for fuel supply; while awaiting their turn operators of such motor vehicles tested the motor operation, cleaned their carburetors, greased their machines, etc., all of which added considerably to the pollution of the atmospheric air and of the soil.

In the course of our air sample study for tetraethyl lead we observed that after the washing off of the lead iodide precipitate there remained on the surface of the porcelain dish a tar-like coating, which fluoroscopically yielded a bluish-violet fluorescent light. Further studies of tarry substances were limited to qualitative tests. No special investigation of their properties were undertaken. It was noted, however, that in samples collected during the summer season such fluorescence was more clearly defined than in samples collected in the fall; we believe this to be due to higher summer air temperatures which tended to volatilize the tarry substances to greater air

concentrations. From this point on we regarded the presence of such tarry substances as one of the indicators of pollution of atmospheric air in the vicinity of gasoline supply centers.

We are forced to assume that non-observance of regulations applicable to storage and supply of ethylated gasoline, careless maintenance at the point of gasoline distribution and the manual method of supplying it contributed to the air and soil pollution of the auto fuel storage and supply centers at the sovkhoses investigated.

Eighty inhabitants of the sovkhoses Zernovoi and Imeni Radishcheva who resided up to 100 m from the storage centers were questioned regarding possible air pollution effects. Fifty-three complained about the unpleasant gasoline odor coming from the storage centers; 21 persons ascribed frequent headaches and nausea to the presence of gasoline odor; 9 persons stated that they suffered of eye burning and irritation when the wind blew from the gasoline supply center in the direction of their residences. In summary, it can be stated that atmospheric air pollution extended as far as 100 m from the center of gasoline supply and soil pollution up to a distance of 50 m. Simple hose gasoline supplying did not appear to be a worthwhile improvement over manual gasoline distribution in so far as air and soil pollution were concerned. This was clearly indicated by the fact that in the supply centers of sovkhoses Dekabrist, Komsomol'skii and Krasnyanskii, where gasoline was distributed with the aid of a rubber hose, the atmospheric air and soil pollution were as intense as in the other sovkhoses which used the manual method of auto-fuel distribution. In view of the above it is felt that the presently prescribed 75 m sanitary clearance zone between gasoline storage centers and residences is inadequate. Our agriculture is growing and with it the use of automotive power is also growing; as a consequence the kolkhoz and sovkhos autoparks and auto-fuel supply centers will cover larger areas and will increase the volume of dispensed auto-fuel. It is suggested, therefore, that the problem of sanitary clearance zones applicable to conditions under discussion be reexamined with a view to widening them. In addition, protective health measures for those employed in the various phases of gasoline handling in connection with automotive agricultural machinery, should be prescribed by laws. This recommendation applies as much to protection of soil as well as

of air from pollution by factors under consideration. Responsible local sanitary organizations must do all in their power to institute methods of gasoline dispensing to automotive vehicles and agricultural machines which would obviate any spilling or leakage of gasoline.

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Ratio of Sulfur Dioxide and Sulfuric Acid Aerosol in Atmospheric Air,
in Relation to Meteorological Conditions.

By

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(From Erisman Scientific-Research Sanitation Institute).

Gigiena i Sanitariya, No. 11, 11-13, 1954.

The widespread poisoning which occurred among populations of foreign cities with developed industries attracted considerable attention in recent years. According to records these poisonings happened under unfavorable meteorological conditions, such as continuous fogs, stagnant air and temperature inversions. These poisonings were traced to atmospheric air pollution caused by industrial emissions, the effects of which were intensified by the unfavorable meteorological conditions.

The first case on record occurred in December 1930 in the Maas River Valley, Belgium. Similar cases were recorded in October 1948 in the industrial area of Donora, Pennsylvania, U.S.A., and in December 1952 in London. All persons affected suffered of respiratory tract and cardiovascular disturbances. The toxic fogs most severely affected the aged and children. No definite proof exists as to what particular substance may have been the cause of such extensive poisonings, although most investigators are of the opinion that the presence of sulfur oxides in the air may have been the basic causative factor. Such authors as Batta, Fircet and Lecler assumed that the cause of the poisonings was the combined effect of sulfur dioxide and sulfuric acid aerosol.

Sulfuric acid aerosol is toxic. P. Drinker stated that exposure of guinea pigs for 72 hours to the action of sulfuric acid aerosol at a concentration of 8 mg/m^3 resulted in grave pulmonary damage. Coste, Courtier, Mader, Hamming and Belling believe that the formation of sulfuric acid aerosol in city atmospheric air may take place during foggy weather. However, their assumption is based on scattered incomplete observations; it needs to be verified. Furthermore, the fact of the transformation of sulfur dioxide in the air of populated places into sulfuric acid has not been proved, and the conditions upon which such transformation may be contingent have not been established.

To accomplish this the present author analyzed the atmospheric air of Moscow for the presence of sulfuric acid aerosol in an attempt to determine

whether or not its presence was in any way related to the oxidation of sulfur dioxide. At the same time it was necessary to determine what correlation, if any, existed between the concentrations of these two air pollutants and to find the conditions which determined their ratios. One-hundred-ninety-eight 24 hour samples and 50 single concentration samples were collected simultaneously. For the determination of sulfuric acid aerosol, the air was aspirated through an absorber equipped with a porous glass filter No. 2 and containing 4 ml of twice-distilled water; a small tube containing lead peroxide was placed before the absorber for the removal of sulfur dioxide. Samples to be tested for the presence of sulfur dioxide were collected into an absorber equipped with a porous glass filter No. 1 and filled with 6 ml of a 6% solution of potassium chlorate. The correlation between mean daily concentrations of sulfuric acid aerosol and sulfur dioxide is shown in Fig. 1.

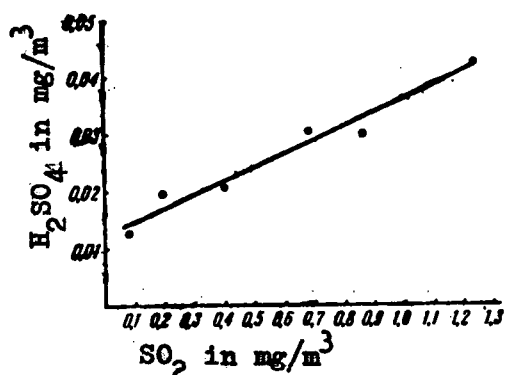


Fig. 1. Correlation between H_2SO_4 and SO_2 concentrations

Fig. 1 shows that an increase in the sulfur dioxide concentration was paralleled by an increase in the concentration of sulfuric acid. On the basis of this it can be assumed that the two pollutants have a common origin.

A study was then made of the relations, if any, between the ratio of H_2SO_4 aerosol and SO_2 concentrations and meteorological conditions, such as relative humidity, velocity of wind and the type of weather. The results are shown in Fig. 2.

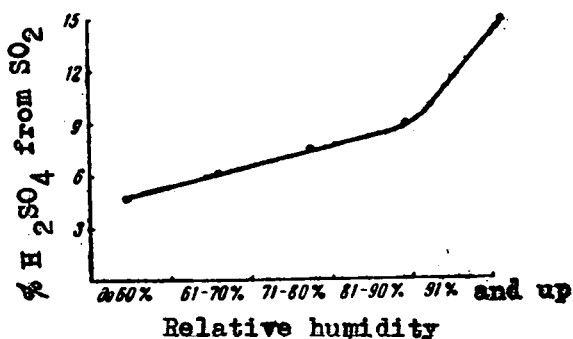


Fig. 2. Effect of air moisture on H_2SO_4/SO_2 ratio

The data plotted in Fig. 2 indicate that as relative humidity rose the ratio of sulfuric acid aerosol concentration to the concentrations of sulfur dioxide increased. Such a condition prevailed in the case of the 24 hour average and single concentration air samples. Precipitations removed a considerable por-

tion of the sulfuric acid aerosol from the atmospheric air, thereby lowering the ratio of H_2SO_4 aerosol to SO_2 . This was due basically to the fact that sulfuric acid aerosol, being highly hygroscopic, was removed from the air at

a higher rate than the SO_2 . These observations accord with the opinions of some authors who believe that the process of oxidation of sulfur dioxide takes place not in its gaseous form but in the liquid phase: the SO_2 was first absorbed by the water; in the dissolved form it was adsorbed by dust particles, and only then became oxidized to H_2SO_4 . Furthermore, concentrations of sulfuric acid aerosol may become markedly increased in the absence of winds. Available data indicate that concentrations of sulfuric acid aerosol during calm days may be 4 1/2 times greater than during windy days with a velocity greater than 5 m/sec.

The ratio of single concentrations of sulfuric acid aerosol to those of sulfur dioxide increased as the wind velocity decreased. This phenomenon can be explained by assuming that an air mass moving through a city at a lower rate requires a longer time for the oxidation of a greater quantity of sulfur dioxide to sulfuric acid. Data related to this phase of the study are plotted in Fig. 3.

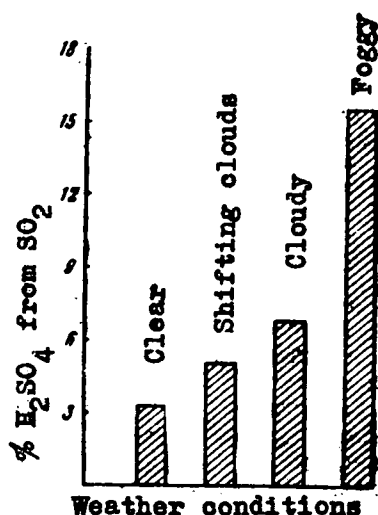


Fig. 3. Effect of weather on correlation between H_2SO_4 and SO_2 .

The data plotted in Fig. 3 indicate that the ratio of sulfuric acid aerosol to sulfur dioxide constituted 3.2% during days with variable cloudiness, 6.8% during days with overcast skies, and 15.7% during foggy days. No periods of lasting fogs occurred during this study. The most persistent fog lasted for 11 hours; during that day the ratio of daily average concentration of sulfuric acid to the concentration of sulfur dioxide was 30%. During fogs lasting 7 hours this ratio decreased to 20 - 24%. During shorter periods of foggy weather this ratio decreased to 10 - 18%. Single concentration air samples obtained during foggy days showed that the average

ratio of SO_2 to H_2SO_4 was 32%. It follows that the ratio of concentration of sulfuric acid aerosol to sulfur dioxide and the absolute concentration values of sulfuric acid aerosol increased during continued fogs.

The results obtained in this investigation accord with the assumption advanced earlier by many authors, namely, that sulfuric acid aerosol can accumulate in the atmosphere of a city during calm foggy days. These results support the hypothesis that the cause of the widespread poisonings in the Maas River Valley,

in Donora and in London, which occurred during calm foggy weather lasting for several days, was the highly toxic sulfuric acid aerosol formed by the oxidation of sulfur dioxide, or the combined action of the sulfuric acid aerosol and of the sulfur dioxide.

More observations are needed for further substantiation of this hypothesis.

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Effect of High Air Temperature on Biochemical Processes in Vivo.

By

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Gigiena i Sanitariya, Vol. 24, No. 1, 30-34, 1959.

In setting standards related to industrial micro-climatic (indoor) conditions it is not enough to base such standards on the usual physiological indexes prevailing under normal conditions, changes in specific metabolic processes of the organism caused by temperature, pressure, humidity and other meteorological conditions must also be taken into consideration. A study of the literature indicated that immediate temperature conditions markedly affected the state of the organism's metabolic processes.

Publications coming from the laboratory of Professor I. P. Rozenkov during the thirties indicated that high temperature changed the degree of oxygen blood saturation, affected the course of oxidation and metabolic processes in the organism, thereby disturbing the alkali-acid balance in the blood of animals

and man. Similar temperature effects were described by M. Blinova, S. E. Severin, Ye. F. Georgievskaya, G. V. Dervis, A. M. Mittel'shtedt, and others. A. Yu. Tilis, Ch. I. Burshtein and other studied the effect of high temperature and irradiation on the blood sugar, alkali reserve, etc., in animals and man during the post-war period. In 1953 E. A. Rozin published the results of his studies on enzyme oxidation and reduction processes in tissues, particularly of dehydrogenase and cytochrome-oxidases. His results indicated that the rate of the oxidation-reduction processes decreased as the temperature increased. A. L. Izbinskii, T. A. Achkasova and other studied the effect of low temperature (cooling) on the rate of metabolic processes. Results of studies by S. S. Girgolav, T. Ya. Ariev, and others established that the onset of changes in the rate of tissue oxidation processes were symptoms of the critical pathogenic moment in the course of cooling the organism.

The above brief review indicates that the published data confirm the occurrence of changes in the biochemical processes of the organism, including the oxidation and reduction processes, caused by some meteorological effects. On the other hand, the available published information was contradictory, due to the fact that the studies were made under different conditions. In the majority of cases the investigations dealt with temperature effects of short duration; under industrial conditions such effects are usually of long duration. No information was found relative to changes in biochemical processes consequent to meteorological variations despite the fact that knowledge of these changes is of particular interest.

The present report is a preliminary one; it describes the results of investigations of some biochemical processes of the organism under the effect of high air temperature. Test animals were subjected to the effect of 40° for three hours daily, over a period of four weeks. Records were kept of body and skin temperature, of respiration frequency, before and after the experiment, and of the weight of the animals. Every five days the blood was analyzed for reserve plasma alkalinity and for sugar. Results were compared with data obtained from a control group of animals kept in a vivarium at 18 to 22°. The rations for the control and test animals were the same throughout the experiments. The alkali reserve of the whole blood was determined by the Van Slyke method, titrated alkalinity of plasma was determined by Panisyyak's method, blood sugar was determined by the Hagedorn-Jensen method.

After the animals had been kept three hours in the heat chamber, the skin

temperature rose by 2.5 to 3° and the body temperature by 1.5 to 2°. The body temperature rose to 40.5 - 41.3°. The respiratory rate increased to 150, and in some cases to 270 per minute. The animals were in a state of high locomotor agitation. After the exposure to high temperature was discontinued the physiological indexes rapidly returned to normal: at the end of 30 to 45 minutes the skin and body temperature and the frequency of respiration fell back to their normal levels.

During the second and third weeks of experimentation the rise in the skin and in body temperature caused by the exposure to heat in the chamber did not reach the same level as during the first week, ranging between 40 to 40.5°; the animals were less agitated, and their rate of gain in weight increased; it appeared as though the animals became physiologically adapted to the new temperature environment. Results of plasma alkalinity, alkali reserve and of blood sugar during the animals confinement in the high temperature chambers are shown in Fig. 1.

Fig. 1 shows that titrable plasma alkalinity fell to 86 - 79% of the initial level. There was also a parallel drop in the alkali reserve of blood to 91 - 85% of the initial level. Prolonged exposure to high air temperature brought about hypoglycemia, symptomatic of accelerated metabolism. The hypoglycemia pointed to an increased tissue sugar consumption. This agrees with the observations of E. S. Novakovskaya and N. B. Kozlov who found that the blood sugar level of overheated animals fell below the normal level. The same author also found elevated levels of insulin in the blood in overheated hypoglycemic animals. It was also noted that high temperature of the surrounding air disturbed the process of sugar metabolism and resulted in the accumulation of incompletely oxidized products of disturbed carbohydrate metabolism. This appears to be substantiated by the drop in the alkali reserve and particularly in the titrable plasma alkalinity.

The present data related to the fall in the alkali reserves of the blood caused by high air temperature agree with the results of investigations carried out by Ch. I. Burshtein and A. Yu. Tilis who exposed dogs to solar overheating. Burshtein and Tilis were of the opinion that the observed changes were intimately connected with the accumulation of incompletely oxidized metabolic products in the blood.

Data related to the state of alkali reserves during heat exposure and after its cessation are of great interest. The accompanying diagrams indicate that

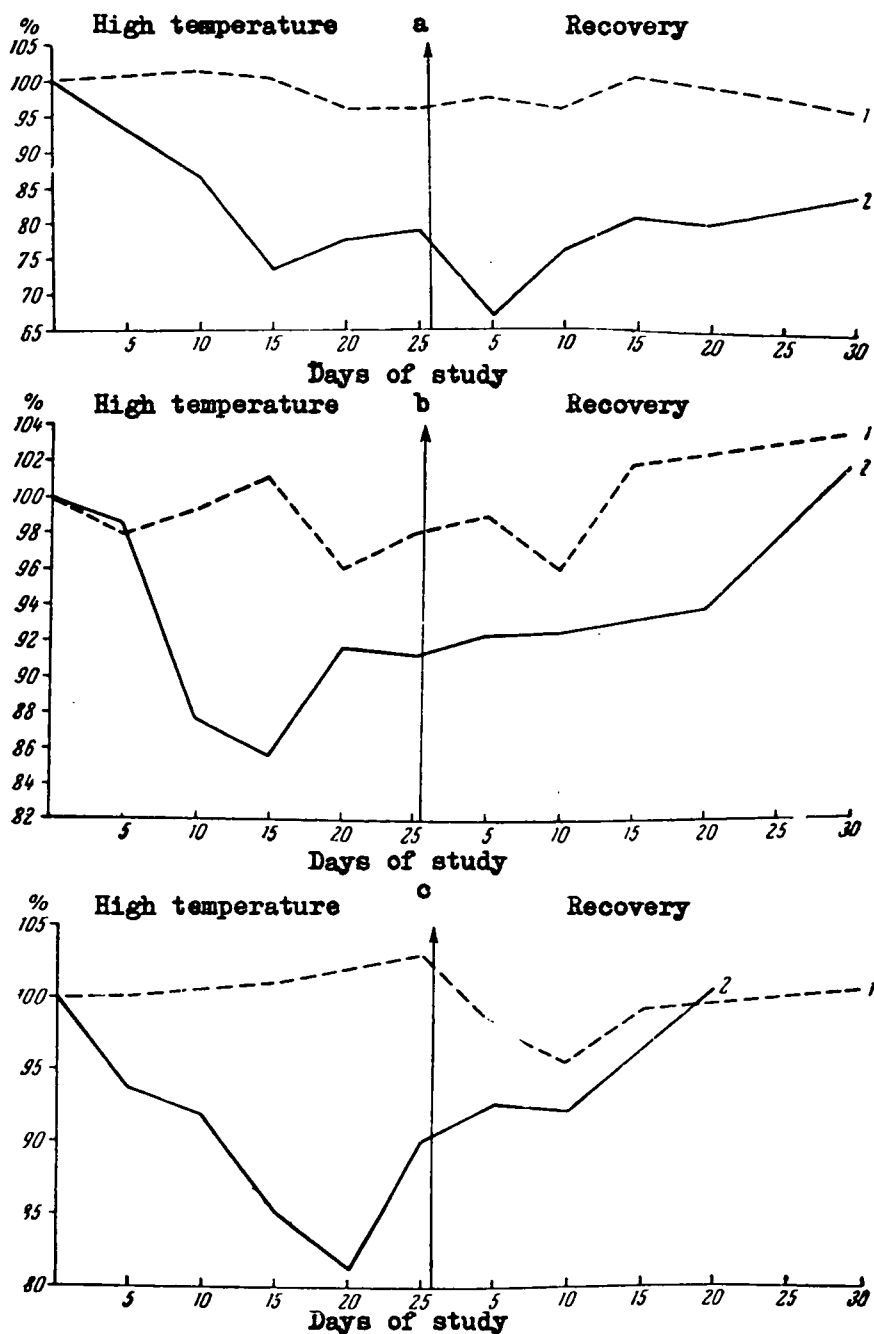


Fig. 1. Effect of high air temperature on: a - titrable plasma alkalinity; b - alkaline blood reserve; c - blood sugar
1 - control group; 2 - experimental group.

cessation of the thermal effect did not create specific conditions for the prompt return to normal of the indexes under investigation. Between the 5th and 10th day after the completion of the experiment the plasma alkalinity, the alkali blood reserve and the sugar content were markedly below the initial values. Even between the 15th and 20th day return of the indexes to their normal levels was still incomplete. The plasma alkalinity remained below the initial level 30 days after the experiment had been completed. It is the opinion of this author that the prolongation of the aftereffects of exposure to high air temperature was of significance, even though it had been disregarded in the past. It was indicated by the results that while such physiological indexes as body and skin temperature, and pulse frequency were restored to their normal upon cessation of high temperature exposures, the metabolic processes of the organism retained their functional shifts for a long time.

Results of studies carried out by the author on oxygen saturation of man's blood under conditions of thermal irradiation were of some significance. Radiant heat of 1.5 to 2 cal/cm² per minute was directed at the right side of the chest of a fully dressed patient for one hour. Oxygen saturation was determined by means of Kreps oxygenometer and was expressed in percent. Simultaneous observations of skin and body temperature, pulse rate, and the patient's heat sensation were recorded. The results indicated that under the conditions of the exposure and intensity the irradiation elicited a slight rise in the skin temperature of the chest under the garment, increased perspiration, and

changed the heat sensation into a feeling of pleasant warmth. The body temperature was not elevated, and blood oxygen saturation manifested a series of changes as illustrated in Fig. 2.

Beginning with the time of the 2nd to the 4th minute of irradiation oxygen saturation of blood began to de-

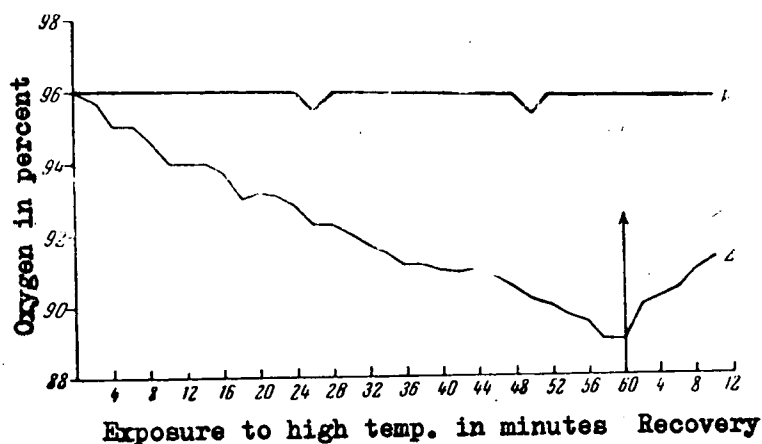


Fig. 2. Oxygen blood saturation during exposure to 1.5 cal/cm²/min of test subject S. Plots represent averages of ten tests. 1 - control data; 2 - experimental data.

crease steadily and progressively; by the end of the irradiation, i.e., on the 60th minute, its level dropped to 89 - 88% of the original and in some cases lower. Cessation of irradiation was followed by an immediate increase in oxygen saturation of the blood; on the 8th to 10th minute its level rose to 93 - 94%. Irradiation of the patient by a beam with an intensity of 2 calories elicited a slightly greater decrease in oxygenous saturation, although there was no complete correlation between the irradiation intensity and the fall in oxygen saturation of the blood. A decrease in oxygen saturation of the blood during irradiation indicated an increased oxygen consumption by the tissues, which may have been caused by changes in the metabolic processes.

Conclusions.

1. Daily three-hour exposure of animals to a surrounding temperature of 40° resulted in a sharp fall in plasma alkalinity, the alkali reserve of the blood and its sugar level.
2. Changes in the biochemical indexes under consideration were observed long after the cessation of the thermal effect, pointing to the persistent nature of the aftereffects.
3. Irradiation of patients by a beam of 1.5 to 2 cal/cm² per minute intensity results in a marked decrease in oxygen saturation of the blood.
4. The solution of hygienic problems related to surrounding micro-climatic conditions should be based on a study of changes in the metabolic processes elicited by micro-climatic (indoor) meteorological conditions.

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Selection of Air Intake Points for Ventilation of Premises in Petroleum Processing Plants.

By

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(Ufa Petroleum Scientific-Research Institute).

Gigiena i Sanitariya, No. 8, 27-34, 1954.

Atmospheric air over the grounds of petroleum refineries always contains some toxic admixtures. Such air pollution is frequently considerable and the utilization of the air for ventilation of premises becomes impossible. Specific conditions of oil processing plants, particularly of those which process sulfur-rich oils, made the task of providing clean air for ventilation a serious and difficult problem.

Some authors suggested purification of air for ventilation through special filters, such as carbon. This method can provide air of sufficient purity, but it is expensive and massive. Other authors suggested that air filtration be abolished and air intake points be located at higher levels. However, in practice it can not always be established at what particular height air intake should be placed. There still is no single answer to this question, and decisions of investigators differ sharply.

The first attempt to find practically acceptable height levels for air intakes was made by M. I. Fonganz and E. E. Gamarnikov¹; following an investigation of atmospheric air in one oil refinery, these authors concluded that even under most unfavorable conditions of refinery building location with regard to hydrogen sulfide accumulation, the air intakes located 18 - 20 m above the ground could supply air sufficiently pure for practical ventilation. These authors concluded further that under favorable conditions of prevailing winds, which do not pass through zones of possible hydrogen sulfide accumulation, the air intake can be lowered to 12 - 15 m.

Such conclusions appeared attractive to organizations which were engaged in planning production plants having highly efficient ventilation systems. Indeed, a system of air intake from the height of 15 m is simple and inexpensive. As a result, such air intake point and air conduits were included in the plans

¹ M. I. Fonganz, E. E. Gamarnikov. Hygiene of Labor in Production and Processing of Polysulfide Petroleum. M. Medgiz, 1949.

for many oil refineries. Some planning organizations firmly believed that the problem of air intake ventilation on the premises of oil refineries found its final solution. Factually this was not the case. M. I. Fonganz and E. E. Gamarnikov proceeded from erroneous premises and came to the wrong conclusions. One of the main errors of these authors is in the evaluation of air quality only on the basis of hydrogen sulfide concentration, assuming that the quantitative content of this substance in some measure determined the quantity of other toxic admixtures. Hydrogen sulfide is one of the most poisonous components of atmospheric air in oil refineries, but many other substances must also be taken into consideration, such for example, as hydrocarbons, carbon monoxide and sulfur dioxide. The density of these gases, carbon monoxide excepted, differs considerably from the density of hydrogen sulfide and, therefore, conditions of their distribution in the atmosphere differ correspondingly. This means that distribution of hydrogen sulfide in the layers of air at different heights does not follow the pattern of general distribution of other gaseous admixtures. Accordingly the work of M. I. Fonganz and E. E. Gamarnikov can be considered as directed toward obtaining air free of hydrogen sulfide, but not air free from other pollutants and suitable for plant ventilation.

From this point of view the conclusions of the above authors seem to be principally in error. In the first place air samples were not taken simultaneously at different levels, which could result in a collection of chance figures having no relation to any regularity. Secondly, the study was limited to one plant in which conditions related to the type of fuel, raw materials, refining conditions, number and size of installations may have been different from corresponding conditions in other plants. Results of an investigation carried out in an oil refinery by the authors of this report confirm the preceding statement. Air samples taken simultaneously at 5, 10 and 15 m above the ground were analyzed by the usual methods for the content of hydrogen sulfide, hydrocarbons, carbon monoxide and sulfur dioxide. The results are presented in Tables 1, 2, 3 and 4.

In installation No. 1 hydrogen sulfide was found only once in identically insignificant concentrations practically at all levels (Table 1). In this case, the hydrogen sulfide was brought in by a westward wind from an oil collector located at a distance of about 0.7 km; there were no other possible points of H_2S origin.

Table 1. Results of atmospheric air analyses in the vicinity of installation 1

Dates of analyses	Air temp.	Pressure mm Hg	Wind		H ₂ S in mg/li			SO ₂ in mg/li		
			Veloc. m/sec	Direction	5 m	10 m	15 m	5 m	10 m	15 m
28/XII 1951	0°	756	3,7	Westerly	0,0004	0,0003	0,0003	—	—	—
29/XII 1951	-3°	758	2,3	South-Westerly	—	—	—	0,006	0,006	0,006
29/XII 1951	-3°	758	2,3	—	—	—	—	0,006	0,006	0,006
30/XII 1951	-2°	763,5	2,8	—	—	—	—	0,009	0,006	0,006
30/XII 1951	-2°	763,5	2,8	—	—	—	—	0,004	0,004	0,006
30/XII 1951	-2°	763,5	2,8	—	—	—	—	0,006	0,006	0,006
2/I 1952	-9°	757	3,2	Southerly	—	—	—	0,009	0,009	0,009
2/I 1952	-9°	757	3,7	—	—	—	—	0,006	0,007	0,007
3/I 1952	-12°	758	2,4	—	—	—	—	0,0009	0,004	0,004
3/I 1952	-12°	758	2,0	—	—	—	—	0,004	0,004	0,004
3/I 1952	-12°	758	3,0	—	—	—	—	—	0,0009	0,003
4/I 1952	-15°	759	4,5	—	—	—	—	0,006	0,002	0,0008

The distance from the test site and the low capacity of the source explain the uniformity of H₂S distribution and its insignificant concentration. During all other days the wind blew from directions where no hydrogen sulfide was liberated and, therefore, it was not analytically detected. As shown in Table 2 almost all analyses of air samples of installation No. 2 showed the presence of hydrogen sulfide; its maximum H₂S content was 0.001 mg/li at heights of 5 to 15 m on the day the plant underwent an overhauling, and the equipment was opened and drained; analyses made during work hours gave lower results; five air analyses indicated uniform H₂S distribution at different heights, 2 a fall, and one analysis an increase in hydrogen sulfide concentration at 15 m above the ground.

During the investigation directions of prevailing winds excluded the possibility of hydrogen sulfide inflow from other sources; therefore, the hydrogen sulfide must have come from installation No. 2. The low concentrations of H₂S and its uniform distribution at

Table 2. Results of atmospheric air analyses in the vicinity of installation 2

Dates of analyses	Air temperature	Pressure in mm Hg	Wind		H ₂ S in mg/l			SO ₂ in mg/l		
			Veloc. m/sec.	Direction	5 m	10 m	15 m	5 m	10 m	15 m
12/1 1952	-11°	742	0.9	South-Westerly	-	0.0007	0.0002	0.0009	0.0003	-
14/1 1952	-9°	743	1.1	Southerly	0.001	0.001	0.001	0.001	0.001	-
16/1 1952	-7°	744	1.2	South-westerly	0.0002	0.0002	-	0.003	0.001	-
17/1 1952	-3°	745	1.7	Southerly	0.0004	0.0002	0.0002	-	-	-
17/1 1952	-6°	748	1.8	et m	0.0004	-	-	0.001	-	-
29/1 1952	-15°	759	1.2	South-Westerly	0.0002	0.0009	0.0002	0.0009	0.0009	0.003
29/1 1952	-15°	759	1.2	.	0.0009	0.0009	Her	0.0009	0.0009	0.0009
30/1 1952	-20°	761	0.03	.	0.0004	0.0004	0.0004	0.0009	0.0009	0.0009
30/1 1952	-20°	761	0.03	.	0.0004	0.0004	0.0002	0.0009	-	-
30/1 1952	-20°	761	0.03	.	0.0002	0.0002	0.0002	0.001	0.001	0.001
1/1 1952	-5°	761	0.06	.	0.0002	0.0002	0.0002	0.001	0.001	0.001
1/1 1952	-5°	761	0.06	.	0.0002	0.0002	0.0002	-	-	-
1/1 1952	-5°	761	0.06	.	0.0004	0.0003	0.0003	-	0.001	0.001

all levels can be explained by the absence of points of concentrated open hydrogen sulfide emissions and by the fact that H₂S leaked out into the atmosphere in an unorganized manner. Data presented in Tables 1 and 2 indicate that hydrogen sulfide was present in most air samples collected at installations Nos. 1 and 2. Test samples taken at all three levels at installation No. 1 were negative for H₂S in one case only.

Distribution of hydrogen sulfide concentrations according to levels was as follows:

	Instal- lation No. 1	Instal- lation No. 2
Uniform at all three levels	55%	46%
Decrease with elevation increase	18	38
Increase with elevation increase	27	16

Data listed in Table 3 present no regularity in the concentration decrease of hydrogen sulfide or other admixtures at heights up to 15 m. As a rule, hydrocarbons were found regardless of wind direction in concentrations often exceeding the limits of allowable concentra-

Table 3. Hydrocarbon concentrations in the air at installations 1 and 2

Dates of analyses	Air temperature	Pressure in mm Hg	Wind		Hydrocarbons in mg/li		
			Velocity, m/sec	Direction	5 m	10 m	15 m
Installation No. 1							
28/XII 1951	0°	756	3,7	Westerly	0,86	2,1	0,27
30/XII 1951	-2°	763,5	2,8	South-Westerly	0,11	0,5	0,4
8/I 1952	-11°	756	1,3	Southerly	0,1	0,1	0,2
Installation No. 2							
18/I 1952	-2°	746	1,3	South-Westerly	0,24	0,1	0,13
22/I 1952	-3°	745	0,03	.	0,35	0,33	0,21
23/I 1952	-10°	747	1,2	.	0,02	0,1	0,2

tions for air of working premises.

Highest hydrocarbon concentrations were noted at 10 m, that is at the level of ventilation air exhausts coming from the pumping centers. There were cases of increased hydrocarbon concentrations at 15 m. This was due to somewhat complicated circumstances: hydrocarbons came from unaccounted sources, or they were liberated at the installations located near the air sample collection points.

Data presented in Table 4 indicate that in the majority of cases carbon monoxide was present in the air near installation No. 2 at levels up to 15 m in a concentration equal to the limits of allowable concentrations for working premises, and in some instances exceeding them; as was the case with other air pollutants, the distribution at levels up to 15 m was uniform.

The distribution of all air pollutants according to levels during the investigation was as follows: uniform at all levels - 52.4%, decrease with elevation - 29.5%, increase with elevation - 18.1%.

Hydrogen sulfide and SO₂ in the proximity of the installations were present in concentrations below the limits set for working premises. If the data obtained for SO₂ were regarded as approximate representatives of air pollution at elevations up to 15 m,

Table 4. Carbon monoxide concentrations in the air at installation 1

Dates of analyses	Air temper.	Pressure in mm Hg	Wind		Carbon monoxide mg/l		
			Velocity m/sec	Direction	5 m	10 m	15 m
4/II 1952	-10°	762	0,84	South-Westerly	0,02	0,02	0,02
12/II 1952	-3°	761	0,84	North-Easterly	0,03	0,03	0,03
14/II 1952	-6°	760	0,84		0,03	0,02	0,03
5/III 1952	-3°	761	2,24	South-Westerly	-	0,006	-
8/III 1952	-2°	745	1,9		0,05	0,005	0,005

then in the case of hydrogen sulfide, the possibility should be taken into consideration of the inflow of greater concentrations, since at installation No. 1 (and others) a potent source of H_2S liberation was located at a level of 15 m above the ground. It is conceivable that with the wind blowing from this source, the hydrogen sulfide concentrations sharply increased. A similar situation existed at the same installation with regard to hydrocarbons, the concentration of which at the ventilation exhaust level (10 m above the ground) was at a maximum as compared with other levels, and exceeded the limits permissible for working premises. Such an assumption was verified by the investigations of L. I. Los' and his collaborators.¹ L. I. Los' investigated a refinery and found the ventilation air to be polluted by hydrogen sulfide and hydrocarbons, despite the fact that it was taken in through special shafts 14 - 15 m above the ground.

Prof. L. I. Los' recommended that ventilation air be taken at 32 m above the ground. As applied to hydrogen sulfide and hydrocarbons such a recommendation may be more suitable than the recommendation made by M. I. Fonganz and E. E. Gamarnikov. However, in raising the air intake to a height of 30 m it is necessary to make sure that one does not invade the zone of smokestack emission of SO_2 and of CO.

Thermo-Electric Center (TETs) smokestack emissions are liberated at a level of 50 m, so

¹ L. I. Los'. The Influence of Oil Refineries on the Quality of Atmospheric Air. Hygiene and Sanitation, No. 8, 1950.

that in actuality clean air, free from the enumerated toxic admixtures, can be taken in at a height exceeding 50 m.

Conclusions.

1. Under conditions existing in the oil refinery investigated by the authors, as well as in many other refinery plants, the installation of air intakes at 15 - 20 m fails to improve the quality of ventilation air, and in many cases might worsen it.

2. Recommendations made by M. I. Fonganz and E. E. Gamarnikov that fresh air ventilation intakes for refineries be intalled 18 - 20 m above the ground are not applicable to all oil refineries. These recommendations are based on results of studies limited to air pollution by hydrogen sulfide only and can not be used as a basis for generalized conclusions.

3. An appropriate solution of the problem of ventilation air intake can not be achieved apart from the general control of air cleanliness; depending on local conditions, it may involve the adoption of complex of measures, such as the improvement of technological methods, thorough air tightening of equipment and containers, etc. In view of the complexity and specific conditions which may exist in some modern oil refineries, the choice of necessary sanitary measures can be made only on an individual basis by taking into consideration actually existing conditions.

4. Where it may be impossible to assure purity of atmospheric air at a convenient level, a thorough purification of the incoming air should be recommended, by the use of proven effective methods.

Purification of Ventilation Air from Tetraethyl Lead.

By

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(Gor'kii Institute of Labor Hygiene and Occupational Diseases of the
Ministry of Health, R.S.F.S.R.).

Gigiena i Sanitariya, No. 3, 11-16, 1955.

In accordance with the decisions of the XIX convention of K.P.S.S. (Communist Party of the Soviet Union), prevention of diseases must become the most important task of health authorities. Action directed toward the reduction, or the complete elimination, of atmospheric air pollution by the emission of toxic substances and by industrial dusts, should be considered as basic prophylactic measures. In the production of tetraethyl lead (TEL) considerable quantities of ventilation air are ejected into the atmospheric air. In his paper "Hygienic Significance of Atmosphere Pollution in Chemical Plant Areas" ¹ A. S. Arkhipov showed that TEL concentration in exhaust ventilation air emitted into the atmosphere by TEL plants ranged between 0.79 and 36 mg/m³, and in production of ethyl gas between 0.13 and 2.02 mg/m³. In this connection, it should be noted that ventilation air is an important factor in atmospheric air pollution with tetraethyl lead by the above mentioned industries.

Tetraethyl lead is a highly toxic substance deleterious to the human organism in small quantities. According to the data recorded in A. S. Arkhipov's paper TEL concentrations as low as thousandths and ten thousandths of a milligram per liter of air produced chronic intoxication. The TEL molecule is highly stable and persists for a long time under conditions of external environment. The purification of exhaust gases is widely used at present in the control of different types of industrial atmospheric air pollution resulting from different technological emissions by primary production equipment. Until recently few of our industries purified ventilation air from toxic pollutants, chiefly because of weighty technical difficulties. The first is the volume of ventilation air emitted daily which amounted to millions of cubic meters, and the old small-size purification installations could not cope with the situation.

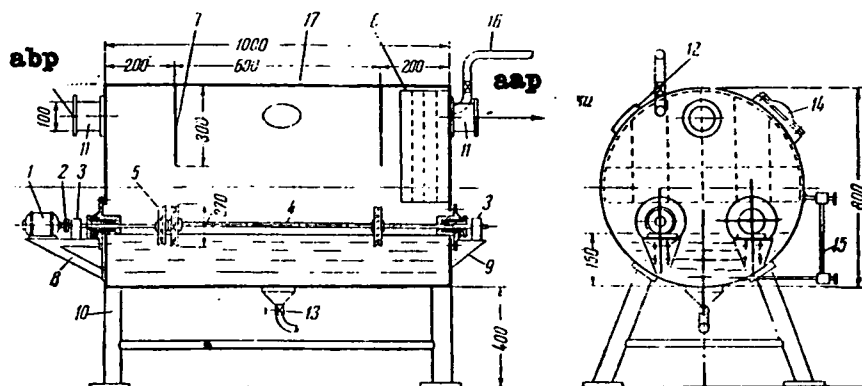
¹ Report thesis of the scientific session of the Sanitation-Hygiene Institute and Hygiene Departments of Medical Institutes, 1953.

The second difficulty results from the relatively low concentrations of toxic substances in the ventilation air.

Some of the investigated plants emitted the ventilation air at 50 to 75 m above the ground without achieving the required reduction of TEL concentration. The high toxicity of TEL, the resistance of its molecule to the effects of external environment and the inadequate dispersion of ventilation air even when emitted at heights of 50 - 75 m are compelling reasons for the need of adequate purification of ventilation air from tetraethyl lead. Attempts were made to accomplish this by means of the I. V. Oreshkevich chemical fluid-filter. The experimental filter represents a horizontal cylindrical reservoir 100 cm long and 80 cm in diameter. Two shafts run parallel to the face walls of the cylinder; to the shafts 12 sprayer-discs are attached rotated by 2 0.25 KW motors in opposite directions at a peripheral velocity of 15 - 20 m/sec. The cylinder is partly filled with the filtering fluid, which contains a suitable chemical for the absorption of TEL. The fluid is poured into the apparatus to a level of 50 - 100 mm above the discs. The level of the fluid is controlled automatically. The filter operates on the principle of atomization of the cylinder fluid, which creates a large surface of contact between the filter fluid and the TEL; it is economical to operate because of its low pressure drop and rate of air aspiration which ranges between 0.3 - 0.6 m/sec. The plan of the filter is presented in the following drawing.

The efficiency of the filter was determined by analyzing air samples taken simultaneously before and after filtering. Samples consisted of 6.3 li of air. Four hundred and six air samples were analyzed in this study, using 0.5% alcohol iodine solution as the absorber. TEL was determined colorimetrically with the aid of dithizone. All tests were made under practical industrial conditions.

Taking into consideration the physico-chemical properties of TEL in conjunction with the low cost requisite of the TEL air purification process, it was decided to perform the preliminary tests with the use of chlorine water, spent lubricating oils and kerosene. As the TEL absorbers additional tests were made with 10% alkaline soap water. Exhaust ventilation air was aspirated through the chemical fluid filter containing the 10% alkaline soap water at the rate of 0.3 m/sec and at 11.2°. The resulting data are listed in Table 1. The results show that with a TEL concentration of 1.22 to 2.3 mg/m³ the average purification amounted to 19.6%.



Plan of wet chemical filter for the purification of exhaust ventilation air in the manufacture of tetraethyl lead

- 1 - Electric motor; 2 - clutch; 3 - bearing; 4 - shaft; 5 - spray disk; 6 - eliminator; 7 - fender board; 8, 9 - extension supports; 10 - legs; 11 - air intake and output extensions; 12 - peep window; 13 - emptying valve; 14 - hatch with peep window; 15 - water level gauge; 16 - solution intake pipe; 17 - filter body.

abp - Air before purification

aap - Air after purification

TABLE 1.

Degree of air purification from tetraethyl lead by 10% solution of alkali.

Tetraethyl lead concentration in mg/m ³			
Before filtration	After filtration	Before filtration	After filtration
1.22	0.92	2.30	1.84
1.38	1.07	2.30	1.99
1.53	1.22	1.84	1.53
1.38	1.07	1.99	1.53
1.83	1.38	2.30	1.99

Ten tests were made using spent lubricating oils as the absorber. The rate of air aspiration through the filter amounted to 0.6 m/sec. Results are presented in Table 2.

It can be seen that atomized spent lubricating oil also yielded unsatisfactory results; the average purification amounting to 30.9%.

Tests were then conducted using a mixture of water with mono- and diethyl-phenylpolyglycol ethers as the absorber. 10 ml of each ester was added to 84

T A B L E 2.

Degree of air purification from tetraethyl lead by
spent lubricating oil.

TEL concentration in mg/m ³			TEL concentration in mg/m ³		
Test No.	Before filtration	After filtration	Test No.	Before filtration	After filtration
1	1.91	1.01	6	1.76	1.65
2	1.01	0.62	7	2.45	1.76
3	1.15	0.62	8	2.29	1.76
4	1.53	0.88	9	1.91	1.65
5	2.14	1.39	10	1.91	1.15

li of water; higher concentrations of mono- and diethylphenylpolyglycol esters caused excessive foaming which clogged the filter. The rate of air aspiration through the filter was 0.3 m/sec and the air temperature 20°. Results of 20 tests are presented in Table 3.

T A B L E 3.

Degree of air purification from tetraethyl lead by
water containing mono- and diethylene ether.

TEL concentration in mg/m ³			TEL concentration in mg/m ³		
Test No.	Before filtration	After filtration	Test No.	Before filtration	After filtration
1	3.0	2.0	11	4.0	2.0
2	2.5	2.5	12	6.0	2.0
3	3.0	2.0	13	6.0	3.0
4	2.5	1.5	14	6.0	4.0
5	4.0	1.5	15	1.38	1.07
6	4.0	2.0	16	0.61	0.46
7	4.0	2.5	17	1.07	0.37
8	5.0	3.0	18	4.44	3.06
9	4.0	4.0	19	6.27	3.98
10	5.0	3.0	20	6.27	3.52

The data show the extreme unevenness of air purification from TEL obtained with the use of this absorber. In tests number 2 and 9 no purification was obtained. In other tests the air purification reached 60 - 66%. Average purification of all 20 tests was 40%.

It is known that an addition of a small amount of household soap to water increased its emulsifying properties. Therefore, its power to purify air from TEL was tested next in 1 and 3% solutions. The 1% solution of household soap

at air aspiration of 0.3 m/sec yielded an average purification of 33.8% and at 0.6 m/sec the purification amounted to 33.6%.

The results of tests with the 3% solution of household soap are presented in Table 4.

T A B L E 4.

Degree of air purification from tetraethyl lead by
3% solution of household soap.

TEL concentration in mg/m ³			:	TEL concentration in mg/m ³		
Test No.	Before filtration	After filtration	:	Test No.	Before filtration	After filtration
1	3.45	2.03	:	6	2.93	1.77
2	3.56	2.03	:	7	3.56	1.77
3	3.56	1.77	:	8	4.33	2.29
4	2.68	1.65	:	9	3.69	2.14
5	2.80	1.77	:	10	4.20	2.29

TEL concentrations in the above tests ranged between 2.68 and 4.33 mg/m³, the air aspiration rate was 0.3 m/sec, the air temperature 10° and average purification amounted to 45.9%.

According to data found in literature, TEL reacted energetically with haloids. Tests were therefore made to verify the effectiveness of using chlorine water as an absorber of TEL from air. Chlorine water was prepared by saturating tap water with chlorine gas. The air was drawn through the filter at a rate of 0.3 m/sec at air temperature of 7°. Results are presented in Table 5.

T A B L E 5.

Degree of air purification from tetraethyl lead by
chlorine water.

TEL concentration in mg/m ³			:	TEL concentration in mg/m ³		
Test No.	Before filtration	After filtration	:	Test No.	Before filtration	After filtration
1	2.30	0.77	:	8	2.30	1.07
2	1.34	0.56	:	9	3.06	1.53
3	1.53	0.76	:	10	1.38	0.31
4	1.53	0.92	:	11	3.21	0.76
5	2.60	1.38	:	12	3.06	0.76
6	2.60	1.15	:	13	3.36	0.92
7	1.68	0.76	:			

As can be seen these tests produced the highest degree of air purification from TEL. The TEL concentrations ranged from 1.34 to 0.36 mg/m³ and average purification amounted to 61.1%.

Knowing that TEL dissolved well in kerosene, the latter was used as an absorber in additional experiments. For the first series of tests a 1:6 ratio of kerosene and water was tested first. The air was drawn at a rate of 0.3 m/sec at air temperature of 17.4°. The results are shown in Table 6.

TABLE 6.

Degree of air purification from tetraethyl lead by kerosene.

TEL concentration in mg/m ³			TEL concentration in mg/m ³		
Test No.	Before filtration	After filtration	Test No.	Before filtration	After filtration
1	1.53	0.15	6	1.91	0.60
2	1.68	0.15	7	1.76	0.45
3	1.15	0.12	8	1.15	0.09
4	1.38	0.12	9	1.01	0.11
5	1.15	0.09	10	1.01	0.11

It is seen from data in Table 6 that with TEL concentrations of 1.01 to 1.91 mg/m³ the air purification in some tests was 90% and above. The average air purification amounted to 85.5%. The next series of 10 tests were conducted with 2:5 ratio of kerosene and water. The TEL concentrations in the air ranged between 1.73 and 2.04 mg/m³, air aspiration was 0.3 m/sec. The resulting average purification was 88.7%, i.e., higher than in the preceding test series.

The next test series were conducted with the same 2:5 kerosene and water ratio, but the air was drawn through the filter at a rate of 0.6 m/sec at a temperature of 11°. TEL concentration in the aspirated air ranged between 2.04 to 4.59 mg/m³. The average purification attained was 86.98%.

Supplemental tests with a 2:5 ratio kerosene and water, 1.91 - 4.2 mg/m³ TEL concentration, 7.6° temperature and 0.3 m/sec rate of air aspiration, produced an average purification of 90.1%. In isolated tests the purification was as high as 96%.

Due to the particular construction of the fluid filter and its mechanism of operation, only the upper layer of the absorber fluid was dispersed into the air. Therefore, the kerosene was poured into the filter simultaneously with the water, which was more economical. The kerosene was regained by blowing

through it sulfur dioxide or chlorine gas. Laboratory tests indicated, that in both cases a crystalline residue precipitated from the kerosene.

The degree of air purification from TEL can be raised by a 2 - 3 stage purification process, using 2 or 3 consecutive filters.

The lowest TEL concentrations remaining in the air after purification were $0.09 - 0.11 \text{ mg/m}^3$ and highest were $0.60 - 0.76 \text{ mg/m}^3$. Average TEL concentrations after filtering in single test series were 0.12, 0.27, 0.22, 0.21, 0.44, 0.29 mg/m^3 . Thus, after purification through the filter, using kerosene as an absorber, residual TEL air concentrations were of the order of ten thousandth of mg/li . According to data presented by the Gor'kii Institute of Labor Hygiene and Occupational Diseases of the Ministry of Health of the R.S.F.S.R., prolonged contact with TEL concentrations on the order of ten thousandths of mg/li produced chronic intoxication. N 101-54 (Official Standard 101 of 1954) prescribed no maximum permissible concentration for TEL. Individual papers suggest that the limit of allowable TEL concentration for workshops be set at $0.01 - 0.005 \text{ mg/m}^3$. No maximum permissible TEL concentration has been established for atmospheric air. The average TEL concentrations obtained in the air purification by means of fluid filters and the use of kerosene exceeded by 12, 27, 24, 54, 42, 58 and 88 times the maximum permissible TEL concentrations recommended for work premises.

With the given method of purifying air from TEL and subsequent emission through gas stacks 50 - 75 m high, followed by dispersion through the air, it was possible to decrease TEL concentrations in the atmospheric air down to the maximum permissible concentration standards recommended for work premises, and possibly even below it.

Conclusions.

1. Effectiveness of 10% alkali, 1 and 3% household soap solution, chlorine water, mono- and diethylphenylpolyglycol esters, spent lubricating oils and kerosene-water mixtures in 1:6 and 2:5 ratios in the purification of ventilation air from low TEL concentrations has been verified.

2. Highest effectiveness was obtained by using 2:5 ratio of kerosene and water and air passage of 0.3 m/sec . Purification reached 90.1 - 96%.

3. Kerosene can be regenerated by using compressed sulfur dioxide or chlorine gas.

4. The results obtained in air purification from TEL in the above experiments were not adequate; therefore, the air was emitted into the atmosphere at great heights to obtain the desired degree of the TEL dispersion.

Disinfection of Air by Dispersion or Evaporation of Lactic Acid.

By

V. I. Vashkov, A. K. Astraf'eva and R. M. Ginzburg.

Gigiena i Sanitariya, No. 9, 40-44, 1950.

Under certain conditions disinfection of air is a sanitary measure of utmost importance. The problem of disinfecting air in the presence of people is a highly complex one, the solution of which is still lacking. The different methods proposed, such as irradiation by ultraviolet rays, dispersion or evaporation of disinfectants have not produced the hoped for results. Particular attention has been given in recent years to the bactericidal properties of triethyleneglycol which, in low concentrations (1 g per 100 to 200 m³ of air) and relative humidity no higher than 60%, destroyed many airborne microbes and viruses, such as staphylococcus, streptococcus, influenza virus, and others. Reference to the bactericidal properties of other preparations were found in Trudy Tsentral'nogo Nauchno-Issledovatel'skogo Desinfektsionnogo Instituta, No. 5, p. 5, 1949.

In the search for suitable disinfectants lactic acid was tested first. Lactic or alpha-hydroxypropyonic acid [$\text{CH}_3\text{CH}(\text{OH})\text{COOH}$] contains an asymmetrical carbon atom and, therefore, is available in three stereo-isomeric forms. The boiling point at 12 mm mercury pressure is 119° and at 0.5 to 3 mm it drops to 82 - 85°; the sp. gr. is 1.2. The bactericidal properties of lactic acid were tested in the laboratory by the methods of evaporation and dispersion.

1. Bactericidal properties of lactic acid vapor. The effect of lactic acid vapor on a culture of Staphylococcus albus suspended in the air was studied in two boxes, one 2 m³, the other 14 m³. The lactic acid was evaporated from a glass container, or small aluminum cups placed over electric hot plates or alcohol lamps at a temperature of 150° to 180°, to concentrations of 5, 7.5, 10, 11.4, 13, 15 and 20 mg per m³ of air, or 1 g per 50 to 200 m³ of air. Air samples of 15 liters were taken from the boxes by aspiration at the rate of 5 liters per minute. Control samples were taken immediately after the culture dispersion and the test samples were taken 10, 20, 30, 45 and 60 minutes after evaporation of the lactic acid.

The air was aspirated through two interconnected absorbers, each containing 20 ml of sterile physiological solution. Three Petri dishes were then

innoculated with 0.1 ml, 0.5 ml, and 0.5 ml of the physiological solution and incubated for 48 hours, after which the colonies were counted. Before studying the bactericidal properties of the lactic acid vapor, attempts were made to determine the falling out rate of the microorganisms suspended in the air. Air samples were taken immediately after dispersion of the culture and 10, 20, 30, 45 and 60 minutes later. The results showed that 1 minute after dispersion of a broth culture of Staphylococcus aureus the average of counts was 10,283 microorganisms per liter of air in the box, 6,839 after 10 minutes, 5,390 after 20 minutes, 3,027 after 30 minutes, 632 after 60 minutes. (The original text gives the number as 7,632 which is obviously an error. B.S.L.). Thus, 37% of the microorganisms settled after 10 minutes, 50% after 20 minutes, 72% after 30 minutes, and 94% after 60 minutes. These data were taken into consideration in evaluating the effectiveness of the disinfectant.

Some chemical disinfectants were effective only at relative air humidity of less than 60%; therefore, the bactericidal properties of lactic acid vapor were checked under conditions of different relative humidity: 53 to 68% and 84 to 89%. The counts are shown in Table 1.

The data show that lactic acid vapor possessed high bactericidal properties for airborne staphylococci. Thus, at 5 mg of the acid per m^3 of air, the number of microorganisms after 10 and 20 minutes were respectively 4 and 10 times less, than in the control. The potency of the vapor increased with its concentration. At vaporization rate of 7.5 mg per m^3 , the number of microorganisms decreased to 1/14 after 10 minutes and to 1/48 of the control after 20 minutes. At vaporization rate of 20 mg per m^3 the number decreased to 1/215 after 10 minutes and to 1/700 of the control after 20 minutes.

An increase in relative humidity had a negligible effect on the bactericidal properties of lactic acid. For example, 10 minutes after the vaporization of 10 mg per m^3 of air at 57 to 68% relative humidity the microorganisms constituted 5.5% of the original number, and after vaporization of the same amount of lactic acid at 84 to 89% of relative humidity the number of microorganisms in the air was 5.9% of the original. These figures lead to the conclusion that for all practical purposes 10 mg of lactic acid per m^3 of air was sufficient for disinfection regardless of the relative humidity.

2. Bactericidal properties of lactic acid spray. The experiment was performed in a $14 m^3$ box. The method of dispersing the culture of Staphylococcus aureus and of sample collecting was similar to the one used in studying the

Table 1. Effect of lactic acid vapor on airborne *Staphylococcus albus*

Test conditions				Microorgan- isms per li of air be- fore disin- fection	Microorganisms per li of air after disinfec.					% Dead microorganisms				
Lactic acid in mg/m ³	No of obsers	Temperat.	Relative humidity		10 min.	20 min.	30 min.	45 min	60 min	10 min	20 min	30 min	45 min	60 min
5	7	15-18°	55-57%	1 183	286	124	99	67	46	75,9	89,5	91,6	94,4	96,2
7,5	5	15-23°	54-68%	5 940	339	122	83	67	30	93,9	97,9	98,6	98,9	99,5
10	7	15-20°	57-68%	5 046	275	187	54	47	45	94,7	96,3	99	99,1	99,1
10	4	15-18°	84-89%	3 628	216	130	80	—	18	94,1	96,4	97,8	—	99,6
11,4	2	15-18°	53-57%	1 955	16	8	7	10	—	99,2	99,5	99,6	99,5	—
13	1	15°	62%	1 746	21	16	16	37	—	98,8	99,1	99,1	97,9	—
15	2	23-24°	66%	6 955	381	45	33	—	16	94,5	99,5	99,5	—	99,8
20	3	22-24°	53-60%	7 733	36	11	6	—	2	99,5	99,9	99,9	—	99,9

bactericidal properties of vaporized lactic acid.

After dispersion of the culture 5 and 10% aqueous solutions of lactic acid were sprayed into the room at a pressure of 2 atmospheres by a glass atomizer for 6 to 10 minutes. The consumption of liquid was determined from the difference in container weight before and after spraying. Room temperature varied between 15° and 17°, and the relative air humidity between 60 to 70%; the exposure lasted 5, 8 and 15 minutes. The lactic acid was tested in concentrations of 5, 6, 8, 9, 10 and 11 mg per m³ of air. The results are presented in Table 2.

Table 2. Effect of lactic acid aerosol spray on airborne *Staphylococcus albus*. Data represent averages of three experiments

Test conditions			No. of microorganisms per liter of air	Dead micro-organisms in %					
Lactic acid mg/m ³	Tem- perat.	Relative humid- ity		Before disin- fection	After disinfect.				
			5 min		8 min	15 min	5 min	8 min	15 min
5	15—17°	68%	3 090	840	860	620	73,3	72,2	80,0
6	15—17°	70%	1 870	520	620	600	72,3	66,9	68,0
8	15—17°	60—68%	3 250	370	110	35	88,6	96,7	99,0
9	15—17°	62—68%	2 900	91	45	25	97,0	98,5	99,2
10—11	15—17°	62—68%	3 000	70	25	23	98,7	99,2	99,2

Results of observations indicated that lactic acid spray was increasingly effective in concentrations of 5 to 8 mg/m³. With a spray dispersion of 9, 10 and 11 mg per m³ of air, 99.2% of the microorganisms were dead after 15 minutes.

The data in Tables 1 and 2 indicate that vaporized or dispersed lactic acid possessed high bactericidal properties for cultures of *Staphylococcus albus* suspended in the air. Thus, at a dispersion of 5 mg of lactic acid per m³, 68% of the microorganisms died after 15 minutes; at similar vapor concentrations, 76% died after 10 minutes. As the lactic acid concentration in the air increased, its effectiveness as a disinfectant rose. In vaporizing lactic acid it should be borne in mind that heating to 140° decomposed some acid into an anhydride. Therefore, it should not be placed directly over an open flame, but vaporized from a vessel suspended 4 - 5 cm above the flame, or it should be placed over a layer of asbestos.

Lactic acid has several advantages over other air disinfectants. It is not alien to the animal organism, since it is contained in food products. It is a flavoring substance and a preservative used in making lemonade, extracts and essences. Since the acid possessed bactericidal and bacteriostatic properties, as it accumulated in fermentation processes, it destroyed the microorganisms responsible for fermentation and putrefaction. Lactic acid is used to destroy bacteria in wine making and beer brewing. It is also used for the preservation of anatomical preparations and microscopic slides.

Lactic acid is used in medicine, e.g., in diphtheria (inhalation of 5 to 6% solutions). It is recommended for achylia in combination with hydrochloric acid. A 1% solution of it is effective as a stomach wash. All this shows that lactic acid can be used safely as an air disinfectant in the presence of humans. V. I. Vashkov's experiments showed that lactic acid vapor in amounts exceeding bactericidal doses by 10 times, or 100 mg per m³ of air, had no effect on white mice.

Conclusions.

Spray or vaporization of lactic acid at the rate of 10 mg per m³ destroyed 99% of the white staphylococci suspended in the air within 15 to 20 minutes. It is harmless to white mice.

Effect of Atmospheric Pollution on the Bactericidal Effectiveness of Solar Radiation.

By

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Gigiena i Sanitariya, No. 8, 15-18, 1954.

Studies of the bactericidal effectiveness of radiation energy were limited to artificially produced radiation. It was established that the range of the

ultra-violet spectrum was the one which manifested bactericidal properties. The latter depended on the wave length and its radiation intensity. According to present-day assumption maximal bactericidal action was exerted by wave lengths ranging between 254 and 257 mμ. Denoting their bactericidal effect as a unity and the radiation effect of other wave lengths in fractions thereof, it is possible to plot a curve of relative bactericidal action of radiation emanation.

It is known that the short-wave range of solar radiation reaching the earth's surface ends at wave length of about 295 mμ. In the polluted atmosphere of industrial cities this limit shifts toward the long-wave range within limits determined by the intensity of the atmospheric air pollution. According to D. M. Tyukov's observations the short-wave range of solar radiation in Leningrad at noon or at the sun's position at 53.6°, terminates on the average at a 304.6 mμ wave length, and only at optimum meteorological conditions does it extend to waves 300 mμ long. Under such conditions the solar spectrum is devoid of radiation of relatively high bactericidal effectiveness. Its highest effectiveness of 295 mμ wave length is 6.6 times lower than the maximum effectiveness of waves 254 mμ long. Nevertheless, the intensity of solar radiation is such that the bactericidal power generated by it is still considerable.

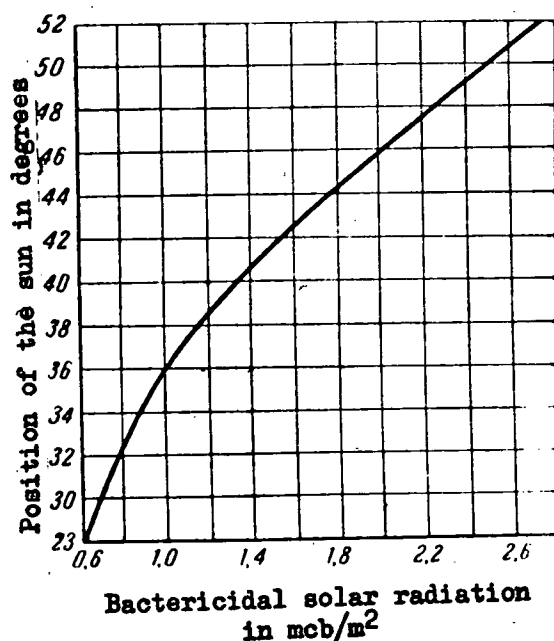


Fig. 1. Bactericidal solar radiation in Leningrad.

Fig. 1 presents a mean curve of the power of bactericidal radiation in mcb/cm² in Leningrad drawn from direct measurements of energy distribution over the solar radiation spectrum.¹

Observations for the determination of the effect of the bactericidal action of solar radiation were made during March and October before and after noon-time while the sun was

¹ Bact. (b) - unit of bactericidal emanation. Bact. is the bactericidal emanation by 254 - 258 mμ wave length, with an energy of 1 w. Microbact. - mcb - one thousandth of a bact.

shining. A strain of Staphylococcus aureus was taken as a test object after its biological properties were established. Petri dishes containing sugar agar were inoculated and exposed to direct solar radiation. The tests were carried out in duplicates: one dish was kept open, the other was covered with ordinary window glass. Exposure time varied from 10 minutes to 2 hours. Bactericidal irradiation fluctuated within the ranges of 10 to 318 mcb/cm². The sun exposed Petri dishes were incubated for 24 hours at 37° C, and the number of developed colonies was counted. Non-irradiated Petri dishes similarly inoculated and incubated served as control. Fourteen series of observations totaling 132 tests were thus conducted.

Fig. 2 presents survival rate curves. The results show that for the destruction of 90% of the staphylococci in the open dish a 12 - 13 mcb/cm² irradiation was required. Further increases in the bactericidal radiation brought about only slightly increasing depressing action. At 90 mcb/cm² radiation surviving microorganisms amounted to 1%. Apparently the surviving microorganisms possessed considerable resistance, as shown by the fact that an increase in radiation up to 318 mcb/cm² failed to destroy them completely. The lowest number of surviving staphylococci amounted to 0.04%.

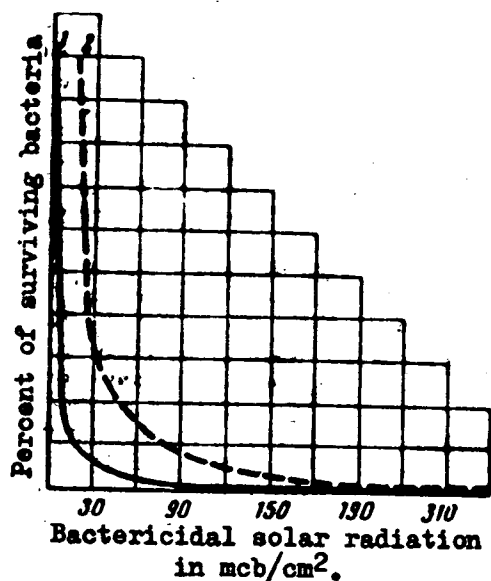


Fig. 2. Percent of surviving micro-organisms.

- 1 - Irradiation in open Petri dishes.
- 2 - Irradiation in Petri dishes covered with window pane glass.

The second curve on the same Fig. 2 shows death rate of staphylococci exposed to solar radiation through window glass. Bactericidal action began to appear at 15 - 16 mcb/cm² radiation. Further increase in radiation intensity led to a slower rate of bacterial destruction as compared with the direct exposure test. At 30 mcb/cm² radiation, the number of surviving bacteria amounted to about 30%, and at 90 mcb/cm² intensity 9% of the staphylococci survived; only at 185 mcb/cm² was the number of viable cells reduced to 1%. No complete sterilization of cultures was observed in either the open or covered dish tests. A comparison of both curves clearly shows that bacteri-

dal effect of solar radiation on hemolytic Staphylococcus aureus was weaker in tests with the glass covered Petri dishes. In order to attain a similar effect, for example, a 90% destruction of the microorganisms, 13 mcb/cm² are required for the open dish radiation and about 80 mcb/cm², i.e., 6 times as much - for the glass covered dish.

One hundred and sixteen strains were isolated for the study of the biological properties of toxigenic Staphylococcus aureus after exposure to solar radiation. The results indicated that a relatively prolonged effect of sun radiation (2 hours) even in the summer at the height of sunshine had practically no effect on pigmentation, and only in a few cases was there weakening in the color intensity. Hemolytic properties and ability to coagulate the blood plasma, tests used in determining the culture's toxigenicity remained unchanged in all the isolated strains.

One of the characteristics of toxic Staphylococcus aureus is its smaller size. Results of observations showed that while biogenic properties of the exposed staphylococci remained unchanged, the size of the cells was notably increased. In addition to the usual grape cluster type of distribution on the microscopic slide there appeared a type of rod-shaped agglutination distribution.

Conclusions.

1. Direct action of solar radiation on toxigenic Staphylococcus aureus cells in open dishes and under conditions of polluted atmosphere destroyed considerable number of them at 12 - 13 mcb/cm² radiation.
2. To achieve equal bactericidal effect in tests with glass-covered dishes a 6 times higher irradiation was required.
3. Isolated strains of toxigenic Staphylococcus exposed to the action of solar radiation retained their hemolytic ability and plasma coagulation, but microscopically the size of the cells appeared enlarged.

An Investigation of the Phytoncidal Action of Live Plants.

By

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Fitontsidy, ikh Rol' v Prirode, Izdat. Leningr. Univ., 22-31, 1957.

B. P. Tokin frequently stated that phytoncides were primarily an ecological problem, which opened up new possibilities for the utilization of plants in the sanitation of the environment in particular for freeing the air from pathogenic microorganisms. It is now certain that volatile and non-volatile active phytoncidal substances emitted by plants into the surrounding medium can affect the microorganisms prevailing in the medium, including the airborne microflora. This highly important aspect of phytoncides has not been fully investigated. Most of the recent research dealt with homogenized ground plant tissues. The value of such procedure applied to the investigation of phytoncides can not be denied. Nevertheless, the present authors believe that the ecological aspects of the problem can not be developed without experimentation with intact, live plants under natural conditions. It is known that tissue grinding disturbed the normal processes of enzyme activity and markedly enhanced hydrolysis and thereby led to the formation of substances normally not present in the tissues of intact plants, or present in minute quantities. Hence, in addition to experiments in vitro, tests should be made with living uninjured and injured plants. Only such a study of phytoncidal activity can offer a basis for the sound selection of plants for the hygienic cleansing of air of pathogenic microbes.

During their investigation of airborne microflora under natural conditions surrounding different plant groupings, Kovalenok, Tokin and Yanovich discovered in 1954 that the composition of air bacteria differed in pine forests, birch groves, thickets of bird cherry, etc. The authors assumed the differences to be due to the specific properties of the volatile phytoncidal complexes emitted by the different plant groups. The present authors undertook to investigate experimentally the way in which the volatile substances emitted by live intact plants affected the microflora of the surrounding atmosphere. The first set of experiments was conducted in a 144-liter glass box equipped with a ventilator, one side of which had a small opening capable of being sealed hermetically.

Two metal tubes were inserted through the bottom of the box at opposite ends. Air entered the box through one of the tubes. To prevent bacteria from gaining entrance into the box during the experiments a cotton plugged curved glass tube was connected to the extruding end of this tube. The second metal tube was joined to the air intake tube of a Shafir apparatus used for the determination of the extent of bacterial air contamination. Shafir's method simplifies the collection of samples. It also serves to maintain the airtight condition of the box, and prevents further pollution of the air during the investigation (Fig. 1).

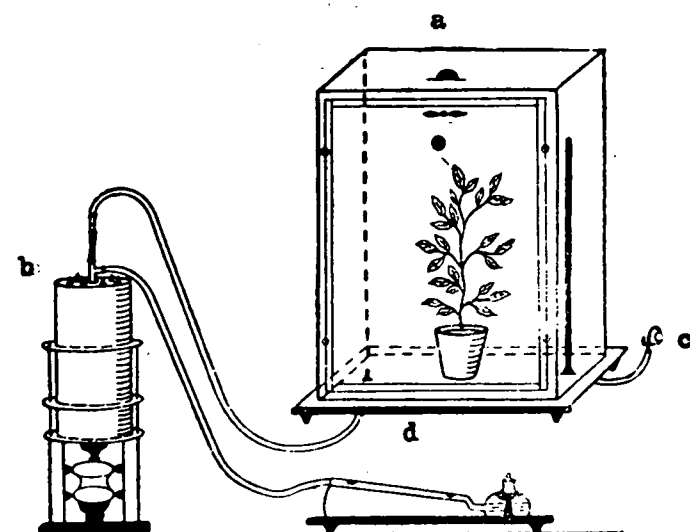


Fig. 1. Setup for the study of intact plant effect on airborne microflora
a - Box; b - Shafir apparatus; c - inflow tube; d - outflow tubing; e - mixing fan.

A known volume of air is passed through Shafir's apparatus for 10 minutes; the air suspended bacteria forced by centrifugal action are caught by a nutrient medium inside special glass cylinders. Meat-peptone agar of pH 7.6 is used as the nutrient medium. The cylinders are incubated at 32°, and the colonies counted after 48 hours incubation.

The effect of plants on the airborne microflora was judged by the number of colonies developed in the sample after 24 hours exposure in the experimental box, as compared with the number of colonies which developed in two controls. There were three air cultures for each experiment; two controls and one test. Ten plant species were tested: Lolium perenne, Festuca rubra, Pelargonium graveolens, Pelargonium zonale, Chrysanthemum indicum, large and small flower, Cyperus alternifolius, Begonia spec., Asparagus spec., and Tuja occidentalis. The house plants were placed in the box in vases, the rye grass and fescue in seed boxes. Nine to eighteen experiments were performed with each species. In addition, there were two series of special control investigations: one an empty box closed for 24 hours, the other box contained a vase with soil but no plants. The results are presented in Table 1.

T A B L E 1.

Effect of some plants on airborne microflora.

Plant species	Number of tests	Average number of colonies in controls	Average number of colonies in tests	Percent reduction in number of colonies
Fuscus rubra	9	33	20	39
Ryegrass, pasture	10	101	43	58
Geranium	18	141	79	43
Pelargonium	9	42	23	45
Chrysanthemum, large	10	93	42	55
Chrysanthemum, small	10	76	26	66
Cyperus	10	99	41	59
Begonia	10	23	13	43
Asparagus	10	39	24	38
Arborvitae	10	48	16	67
Box, no plants	20	74	67	9
Flower vase control	8	29	25	14

The recorded data indicate that under the influence of the plants the number of microorganisms in the box air was considerably reduced. The highest decreases occurred with arbor vitae (67%), small-flower chrysanthemum (66%), galingale (59%), ryegrass (58%), and large-flower chrysanthemum (55%). The effects of the other plants were less significant. The decrease in number of microorganisms in the controls ranged between 9 and 14%.

The decrease in number of microbes in the air in the presence of the plants may have been caused either by (1) the action of volatile substances emitted by the plants, or (2) by the bacteria settling on the plants' surface. The method used in this series of experiments prevented the clear determination of the importance of each of the possibilities mentioned. Therefore, another approach was adopted in the next series of experiments, which made possible the differential study of the effects of volatile phytoncides liberated by live leaves and of other factors. A chamber was set up for the study of the action of volatile phytoncides from leaves of intact plants (Fig. 2).

The chamber was essentially a plastic box 14 x 10 x 1 cm covered by a hinged lid. Fig. 2 illustrates its construction and the method of its operation. Leaves of the intact plant were fitted into the box and the lid was tightly closed. Three sterile glass slides with drops of bacterial suspension in physiological saline were placed over special openings 1 cm in diameter in

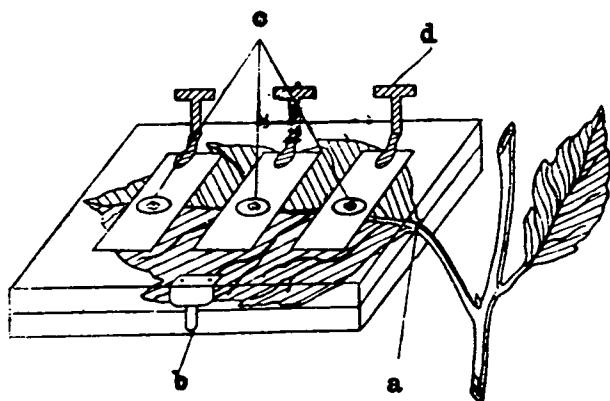


Fig. 2. Apparatus for the study of whole leaf phytoncides
a - Notch for the leaf stem; b - lid lock;
c - round openings for hanging drop preparations; d - clamp fasteners

the lid 2 cm apart. The drops of the bacterial suspension were exposed to the effects of the volatile substances of the plant leaves. The slides were securely fastened with clamps. The microbial suspension 0.3 to 0.5 cm above the leaf surface became engulfed by the vapors of volatile phytoncides emitted by the leaf. The technique of the control tests was the same but the leaves were excluded.

Staphylococcus aureus and Bact. coli (E. coli) served as

the test objects. Eighteen hour cultures of these microorganisms were diluted with sterile physiological saline to a concentration of 1×10^6 bacteria per ml. After 1, 3, 6 and 8 hours exposure the control and test drops were transferred onto meat-peptone agar plates and incubated at 37.0° for 48 hours. The developed colonies were then counted. The experimental data are presented in Table 2.

T A B L E 2.

Effect of volatile phytoncides of live undamaged leaves of some plants on microorganisms.

Plant species	Exposure in hours	Number of developed colonies			
		Staph. aureus		E. coli	
		Control	Test	Control	Test
Geranium (<u>Pelargonium graveolens</u>)	1	1,389	566	-	-
	3	1,700	179	1,303	285
	6	824	0	803	0
	8	-	-	1,370	0
Birch (<u>Betula verrucosa</u>)	1	+	458	-	-
	3	+	178	+	+
	6	517	0	+	+
	8	-	-	+	+
Bird cherry (<u>Padus racemosa</u>)	1	+	+	+	+
	3	+	+	+	+
	6	+	+	+	+

The data show that non-severed geranium leaves emitted volatile substances having antibacterial power against the gram-positive Staphylococcus aureus and the gram-negative colon bacillus. The number of microorganisms decreased in one to three hours after the experiments began. Six hours exposure to the volatile substances of geranium leaves completely sterilized the drops of bacterial suspension. Photographs of the results of one set of experiments are shown in Figs. 3 and 4.

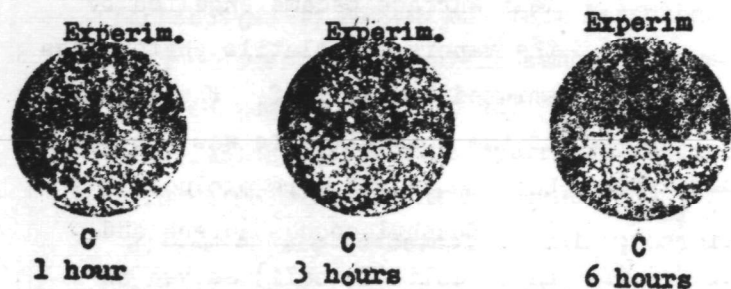


Fig. 3. Effect of volatile phytoncides of live geranium leaves on Staph. aureus. Upper half - experimental; lower half - control

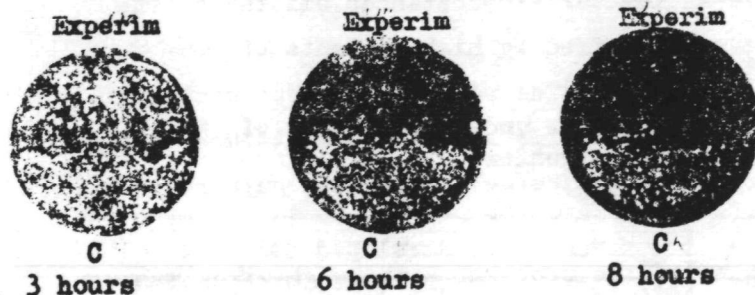


Fig. 4. Effect of volatile phytoncides of live geranium leaves on E. coli. Upper half - experimental; lower half - control

Birch leaves had a similar effect on Staph. aureus. E. coli proved resistant to the phytoncides of birch leaves. Bird cherry leaves manifested no appreciable antibacterial effect.

Comparison of in vivo results with those of in vitro tests brought out noteworthy differences between them.

The comminuted bird cherry tissue emitted a large quantity of volatile substances having potent phytoncidal properties. The unsevered intact bird cherry leaves emitted less of the substance.

The last statement applies only to live, uninjured leaves; specific types of injury caused to the tissues of the

bird cherry brought about the formation of significant quantities of volatile highly active substances as shown in special experiments. According to the literature, ground geranium leaves possessed potent phytoncidal properties. The results of the experiments here recorded showed that intact unsevered leaves of this plant emitted large quantities of volatile phytoncides of marked antibacterial potency and that the emanation of volatile phytoncides seemingly ceased during the process of the plant tissue grinding. Birch tissues manifested

significant phytoncidal activity in the intact and ground up condition.

The results of the experiments herein recorded showed convincingly that some plants, such, for instance, as the geranium and the birch, emitted into the atmosphere large quantities of active phytoncides when intact and uninjured. These plants may be used to free the air of pathogenic microorganisms. Other plant tissues possess marked phytoncidal properties after grinding or after injury and none under normal conditions.

Thus, the experimental results indicated that the degree of phytoncidal action of living uninjured plant tissues at times differed considerably from the action of ground tissues in the same plant. The differences may be attributed to the difference in the chemical structure of the phytoncidal substances and the mechanism by which they are generated in the particular plants. The decrease in number of airborne microorganisms affected by plants may be caused by the volatile phytoncides they emit, and by the settling of bacteria on the plant surfaces as well. Many microorganisms, including pathogens, settle on the surface of leaves, the total area of which is extensive. The question may be asked: what happens to such pathogens? Do they retain their viability or do they perish? The death of the microorganisms settled on the leaves may be caused by non-volatile antibacterial substances emitted by the plants. Some authors described the setting free by higher plants of non-volatile substances toxic to other organisms. The possibility that bactericidal substances may be present in such non-volatile substances emitted by higher plants can not be excluded. Some of Z. L. Galikeiev's 1953 data support such an assumption.

To throw more light on this phase of the problem, a thorough study was made of the effect on the settled microorganism. Leaves of experimental plants were sprayed by an atomizer with a bacterial suspension in physiological saline. Immediately after spraying and also after 1, 3 and 6 hours sections were taken from the same leaf with a sterile cork borer 15 mm in diameter. The sections were placed over the surface of meat-peptone agar in Petri dishes for 10 seconds, and then removed. The Petri dishes were incubated for 48 hours and the developed colonies were counted. By this method it was possible to follow the changes in the number of microbes on the surfaces of the leaves and to determine the degree of their antibacterial effect. Sterile slides were sprayed with the same bacterial suspension and similarly tested for control purposes. In these tests dilutions were used of 18-hour-old cultures of Staphylococcus aureus. A 1 ml

of the dilution contained 1 million bacteria. The experiments were performed in the laboratory during the months of May and June, using intact house plants and leafy shoots freshly cut from trees. The results presented in Table 3 show that most of the Staphylococcal cells on the surface of poplar and birch leaves died during the first 3 hours; in most of the experiments no viable staphylococci remained on the leaf surfaces after 6 hours. Fig. 5 presents photographs of one such experiment.

TABLE 3.

Effect of intact leaves of some plants on golden staphylococcus in direct contact with their surface.

Plant species	Test No.	Staphylococcus aureus impression growth in hours					
		0		3		6	
		Control	Test	Control	Test	Control	Test
Geranium	1	+	+	+	+	+	Single colony
	2	+	+	+	+	+	0
	3	+	+	+	+	+	0
Birch	1	+	+	+	13	+	0
	2	+	+	+	21	+	13
	3	+	+	+	7	+	0
Poplar	1	+	+	+	Single colony	+	0
	2	+	+	+	2	+	0
	3	+	+	+	0	+	0
Arborvitae	1	+	+	+	+	+	33
	2	+	+	+	+	+	57
	3	+	+	+	+	+	Single colony
Bird cherry	1	+	+	+	+	+	+
	2	+	+	+	+	+	+
	3	+	+	+	+	+	+
Linden tree	1	+	+	+	+	+	+
	2	+	+	+	+	+	+
	3	+	+	+	+	+	+

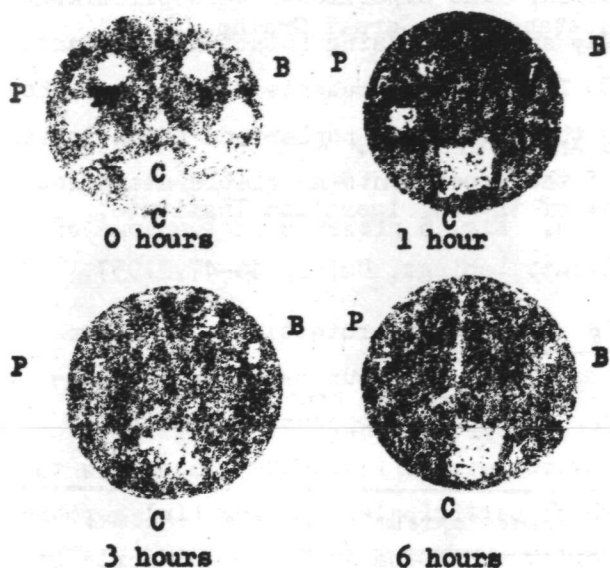


Fig. 5. Effect of live leaves of the poplar and of the birch on surface innucleated Staph. aureus.

P - poplar; B - birch; C - control

Leaves of geranium and of white cedar have well defined, though less potent, antibacterial properties. The effect of bird cherry and linden on Staph. aureus brought into direct contact with the surface of the leaves could not be determined in the laboratory. Thus, the results indicated that certain living intact plants emitted active phytoncides capable of destroying airborne pathogens by: (1) emitting volatile phytoncides, and (2) by generating active phytoncidal substances lethal to microorganisms which settled on the surface of the leaves.

In selecting plants and trees for decorative purposes consideration should be given to their ability to free the air from bacteria. The experiments herein reported indicated that the birch, the poplar, the arbor vitae and the geranium possessed this ability to a high degree; according to M. A. Komarova (1956) the same was true of the fir and the wild rosemary. Future studies will find this to be true of many other plant species. In planning such studies it should be borne in mind that the rate of phytoncide emission by live intact plants does not always coincide with the degree of phytoncidal activity of the ground plant tissues and that an evaluation of phytoncidal properties of live plants on the basis of experiments in vitro may be misleading. The relationship between phytoncide formation in intact plants and the condition and viability of the plants should be regarded as of importance.

Emission of Phytoncidal Substances by Cereal Grains.

By

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Fitontsidy, ikh Rol' v Prirode, Izdat. Leningr. Univ., 40-47, 1957.

The importance of yellow flavonoid pigments in protecting plants from various bacterial infections was discussed in a previous paper on the hip-bearing rose. The antibiotic effect was thought to be connected with the property of aglucones produced by the hydrolysis of flavonoid glucosides to block the activity of enzyme systems which participated in microbial aerobic respiration. A search was made for similar phenomena in the plant world in general. Cereal grains were studied first. Common experience pointed to the fact that grains falling into the soil were not affected by microorganisms despite the fact that the conditions were favorable: abundance of moisture and predominance of microorganisms. Such anti-microbial resistance has been correctly connected with the life processes of the seed or grain. In this connection the question arose: what was the mechanism by which seeds and grains were protected against microbial attack before germination when all vital functions were still inactive? There must be some antibiotic substance or substances which safeguarded the seeds in the moist soil.

Most investigators concerned with the problem of seed germination regard moisture absorption by the seeds as the primary active factor in the process of seed germination. In doing that they lose sight of the fact that moisture is drawn from the grain after its swelling. A. B. Blagoveshchenskii concluded that seed germination was held back by carbonates. Results of experiments in soaking barley seeds led to the conclusion that two processes took place in soaking: absorption of moisture and emission into the surrounding medium of some substances which colored the water pale yellow. A study was made of the nature of these substances and of their biological significance. On the assumption that the substances emitted by seeds during soaking were flavonoid glucosides, attempts were made to isolate them in pure form. Advantage was taken of the fact that glucosides were not precipitated by lead acetate in acid solution; excess of lead was removed by Na_2SO_4 and H_2S . The solution was then concentrated by vacuum evaporation and repeatedly treated with alcohol,

which was driven off by distillation. The isolated flavonoid glucoside fraction was tested for antibiotic properties by the Petri dish and by the dilution methods against different saprophytic microorganisms. The results showed that the preparations possessed a comparatively high bactericidal potency of a broad antibiotic spectrum. Similar preparations were obtained from wheat seeds which were checked for antibiotic effects against phytopathogenic bacteria and, particularly, on bacteria attacking cotton seeds and sprouts. The data are presented in Tables 1 and 2. Tests for the bactericidal effects of the preparations in 1:100 to 1:500 dilutions on the same phytopathogenic bacteria resulted in complete inhibition of bacterial growth. Further experiments showed that treating cotton seeds with the preparation not only inhibited the growth of pathogenic bacteria, but also enhanced germination of the seeds and stimulated growth.

T A B L E 1.

Effect of the preparation on microflora attacking cotton (selection 108 f).
(According to F. B. Khetagurova).

Nature of experiment	Germination in %	Number of colonies		Remarks
		Ps. malva- ceae in 1:1000 dil:	Epiphyte bacteria 1:1000	
Control, untreated	92.0	28	81	Slow germination, bacteria infested crop
Treated with 1:300 dilution of prep'n	93.0	0	0	Active germination, no bacteria infestation
Ditto 1:500	97.0	0	4	Ditto
Ditto 1:700	98.0	0	5	Ditto

It is believed that this phytoncidal effect on saprophytic and pathogenic bacteria was due to the ability of the yellow grain pigments to block enzymic systems of aerobic respiration of microorganisms, and that the pigments played a similar role in the process of seed germination. To check this assumption and to determine the distribution of these substances in the main constituents of barley grains, (capsules, aleuronic layer, and endosperm), extracts were made of such grain and infiltrated into intact and polished barley seeds in purified and unpurified form.

T A B L E 2.

Bactericidal effect in minutes of volatile fractions of the preparation on
phytopathogenic bacteria.

Bacterial species	Dilution of preparation			
	1:0	1:2	1:4	1:10
Bact. arideae	1	1	2	4
Bact. carotovorum	1	1	2	3
Ps. xanthochlorum	1	2	2	5
Ps. heterocephalum	1	3	3 - 4	5
Ps. herbicola	1	2	4	6

Remark: At the end of the time above indicated the volatile phytoncide fractions stopped all bacterial growth.

The method of infiltrating the above-mentioned seed parts with the concentrated extracts was the same as that used to determine germination ability, i.e., each sample consisted of 500 seeds of known moisture content and weight; these were soaked in the corresponding extracts in funnels. The extract concentrations in all samples were equivalent and were calculated on the basis of the reducing substances amounting to 6.5 mg per 1 ml of the solution expressed in terms of glucose. Seeds were soaked in the solution 4 hours, air dried for 16 hours and again soaked for 4 hours in the same solution. Control tests were made in a parallel manner. After 24 hours soaking the swollen seeds were placed for germination in the funnels, covered with periodically moistened filter paper and allowed to germinate. Five days later the rate and extent of the seed germination were determined; the sprouts were separated from the seeds; both were dried to constant weight at 50 to 55°. By the usual gravimetric method the losses in dry seed matter due to respiration and to the sprouts were determined. The experimental data are presented in Table 3.

The results established the fact that biologically active substances present in seeds were concentrated in the peripheral part and were practically absent in the endosperm. Infiltration of these substances into seeds in concentrated form impeded germination and completely arrested losses in dry matter due to respiration. Increase in dry matter noted in the experimental samples resulted from the absorption of these substances by the seeds. The experimental data confirmed the previous assumption that the antibiotic effect on phytopathogenic microflora was due to the arrest of the aerobic processes of microbial cells.

T A B L E 3.

Effect of extracts of constituent parts of barley grain on its own germination.

Nature of experiment	Germination in %	Loss in dry matter on fifth day of growth		
		By respi- ration	By sprouting	Total loss
Intact grain soaked in tap water. Control	96.0	5.06	7.59	12.65
Intact grain soaked in extract of grain epiderm, not purified	0.0	+4.78	0.0	+4.78
Intact grain soaked in extract of grain aleuronic layer, ditto	0.0	+3.56	0.0	+3.56
Intact grain soaked in endosperm extract, not purified	89.0	2.03	3.56	5.59
Intact grain soaked in purified epiderm extract	0.0	+5.50	0.0	+5.50
Intact grain soaked in purified aleuronic layer extract	0.0	+1.99	0.0	+1.99
Intact grain soaked in purified endosperm extract	96.0	8.48	5.97	14.42
Polished grain soaked in tap water. Control	99.0	4.58	9.16	13.74
Polished grain soaked in extract of epiderm, not purified	0.0	+2.52	0.0	+2.52

V. P. Tokin, who first discovered the phytoncidal properties of plants, believed that tissue juices and volatile fractions emitted when the tissues were damaged possessed phytoncidal properties. Most experiments of Tokin and of his associates on numerous plants such as garlic, onion, horse radish, and other indicate that only freshly ground material of such plants emitted volatile substances having potent bactericidal properties. F. I. Shevchenko, A. I. Kazakova and M. P. Tokareva noted that ground garlic dried at 20° retained its antibiotic properties, but lost them completely upon drying at 80°. Their data showed that dry garlic powder was hygroscopic and absorbed moisture when tested by the cup method for bactericidal properties. They were of the opinion that the antibiotic action resulted from the enzymic hydrolysis of the glucoside allin upon the absorption of moisture from the atmosphere. They expressed the

opinion that the formation of the volatile phytoncides was facilitated by crushing the plant tissues, and that intact plant tissues carefully dried absorbed only a slight amount of moisture.

In the opinion of these authors the enhanced emission of phytoncides by ground plant tissues was due to the enlarged surface of the active principles, the role of moisture being confined to creating conditions favorable to enzyme hydrolysis. This opinion gave rise to the assumption that the seed of cereal grasses generated volatile substances having phytoncidal properties.

The following procedure was employed in the first series of experiments. Bacterial emulsions of Bact. prodigiosum, Bact. coli communis and Bact. pyocyaneum were evenly spread with a spatula over the surface of meat-peptone agar poured in Petri dishes, to the lids of which were fastened small dishes containing moistened barley seeds (winter variety, 1955 crop) in the ratio of 0.7 part of water to 1 part of barley. The moistened barley seeds were first kept at room temperature for 4 hours. An inoculated Petri dish with slightly moistened seeds suspended from the dish lid was then incubated at 23 to 25° along with a control dish having no seeds. Twenty-four hours later the agar plate was examined; it showed a zone of no bacterial growth (Fig. 1). Along the edge of the growth-inhibited area there was a zone of depressed growth showing isolated colonies of inhibited development. The zone averaged 2 to 4 cm in width. Beyond this zone the growth of bacteria was normal. It was noted that in the case of pigment-forming bacteria, particularly Bact. prodigiosum, there appeared characteristic color intensification at the pigmentation periphery. The results of the test demonstrated that slightly moistened seeds emitted volatile antibiotic substances.

The next set of experiments was intended to determine the effect of volatile phytoncides emitted by moistened seeds on mature bacterial cultures. For this purpose a 2-day-old culture of Bact. prodigiosum grown on meat-peptone agar was exposed to moistened barley seeds as previously described. Then the experimental and control dishes were incubated at 25°. A day later bacterial lysis was noted, the bacteria-free zone being 22 mm wide. The longer the culture was incubated, the more pronounced was the lysis; after 42 hours incubation the depressed zone averaged 55 mm in width. The data of these experiments are shown in Figs. 2 and 3.

On the basis of the experimental results it was concluded that the volatile substances emitted by barley seeds affected not only young bacterial cul-



Fig. 1.

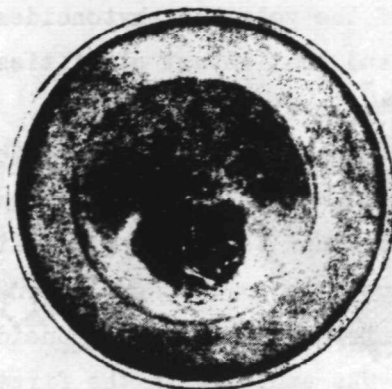


Fig. 2.

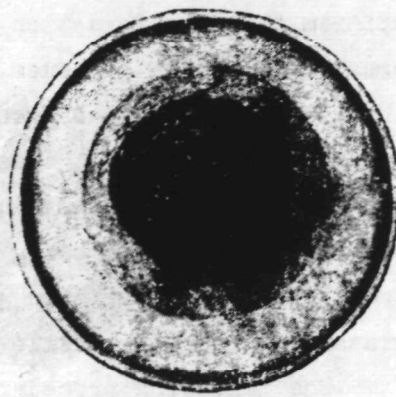


Fig. 3.

Effect of volatile fraction of 24 hour soaked barley grains on:

Fig. 1 - Young culture of Bact. prodigiosum;

Figs. 2 and 3 - 24 hour cultures of Bact. prodigiosum.

tures, but caused the lysis of adult microorganisms. A microscopic preparation of a bacterial culture taken from the edge of the growth-free zone showed disintegration of the bacterial cells with the formation of many metachromatic granules. In experiments with other gram-negative cultures, particularly Bact. aerogenes, Bact. fluorescens, Bact. pyocyaneum, the results were substantially the same. However, no such effect was observable in experiments with such gram-positive microorganisms as Bact. subtilis, Bact. mycoides, Micr. candicans, Micr. carolinus, Sarc. lutea, and Sarc. flava.

Similar tests were made with cereal grains of the 1955 crops of Vyatka rye, Belozernyi oats, and Tulun wheat. All the crops had the same effect on gram-negative cultures, as can be seen in Fig. 4. It should be noted that when the Bact. prodigiosum cultures were transferred from the edge of the sterile zone to fresh meat-peptone agar spontaneous lysis of the culture occurred after 24 hours incubation manifested as isolated sterile zones (Fig. 5). The impression gained was that bacterial cultures exposed to volatile phytoncides emitted by cereal grains began to undergo spontaneous lysis in the next generation.

Conclusions.

1. Swelling seeds emitted into the air yellow pigments with phytoncidal properties, thereby creating a bactericidal zone around the seeds.

2. The antioxidative nature of these volatile substances makes credible

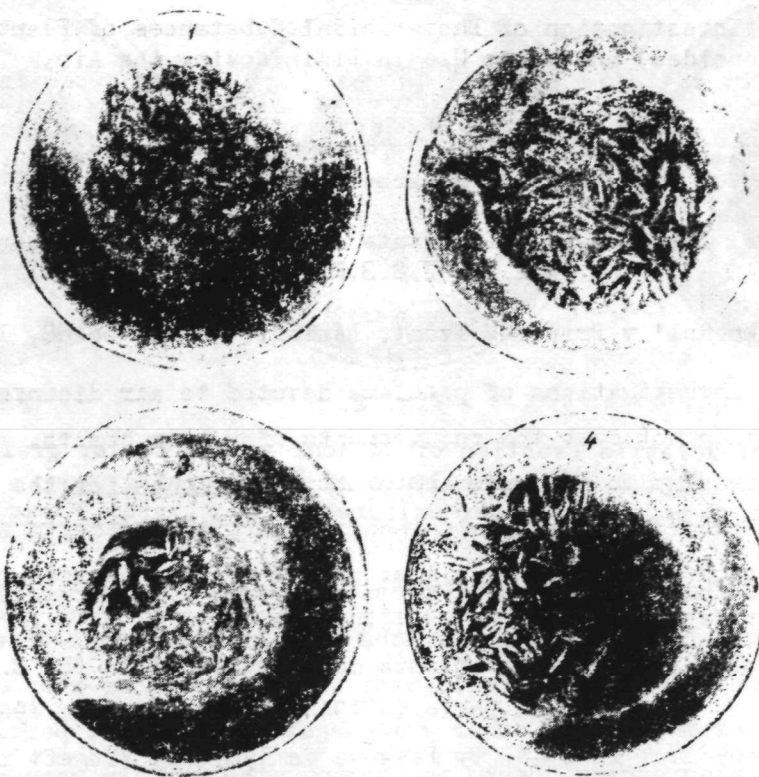


Fig. 4. Effect on Bact. prodigiosum of volatile fractions of:
1 - Rye; 2 - barley; 3 - oats; 4 - wheat.

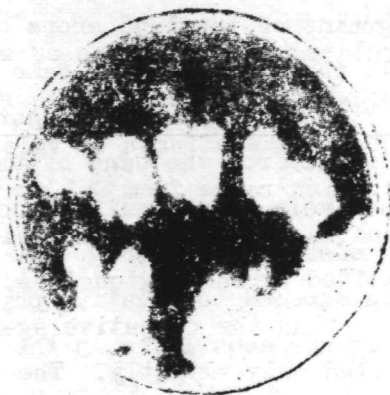


Fig. 5. Spontaneous lysis of Bact. prodigiosum culture following the effect of volatile fraction of barley grains.

grains underwent spontaneous lysis in their second generation upon transfer to a fresh nutrient medium.

the assumption that their emission from the seeds augments the process of germination.

3. Slightly moistened cereal grains emitted volatile phytoncides which lysed mature bacterial cells.

4. These substances affected chiefly the gram-negative bacteria.

5. Bacteria exposed to volatile phytoncides of

An Experimental Investigation of Bactericidal Substances of Plant Origin
(Phytoncides) and Their Use in Disinfecting the Air.

By

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Fitontsidy, ikh Rol' v Prirode, Izdat. Leningr. Univ., 84-88, 1957.

Experimental investigations of problems devoted to air disinfection are numerous, but they do not meet the requirements of public health. Therefore, it was thought necessary to find new and practicable means for the disinfection of air that would accord with hygienic requirements. Experiments were conducted with substances produced by several higher plants for the purification of air with special reference to children's institutions.

Under study were 23 species of plants commonly found in the U.S.S.R. which were investigated by Karelina and Tokin in 1944, by Yanovich in 1944, by Borsova in 1946, by Kovalenk in 1946, by Pevgova in 1949, by Vitgeft in 1949, and by others. A laboratory and field comparison of the bactericidal action of the volatile products of various plants led to the conclusion that the perennial Siberian fir and wild rosemary warranted their further experimental investigation along several lines.

In one set of experiments freshly inoculated agar cultures of staphylococci, streptococci, diphtheria and whooping cough organisms and some representatives of the intestinal bacteria were exposed to the effects of volatile substances emitted by fir needles in a concentration range from 0.1 to 5 g per Petri dish. The growth of the diphtheria and whooping cough bacilli and of the hemolytic streptococci was notably inhibited by the phytoncides. The pyrogenic staphylococci proved more resistant than the causative agents of the children's diseases; their growth was inhibited only slightly. The intestinal and Grigor'yeva-Shiga rods, as well as paratyphoid and dysentary microorganisms were resistant to the action of the volatile bactericides emitted by pine needles.

Cloth materials infected with pathogenic bacteria were suspended in a 10-liter glass vessel containing phytoncide vapors of pine needles; maximum suppression of bacterial growth was observed after a 6-hour exposure. Needles collected at different months of the year varied in their phytoncide activity.

Most pronounced bactericidal effect on diphtheria and whooping cough rods and on pyrogenic cocci was manifested by fir needles collected in April, May and June, i.e., during the prime growing season.

Results of experiments with wild rosemary leaves showed that the phytoncides actively inhibited the growth of diphtheria and whooping cough rods, and to a lesser degree, arrested the proliferation of the hemolytic streptococci and pyrogenic staphylococci; there was a marked inhibition in the growth of the luminescent vibrio. Wild rosemary phytoncides had no worthwhile effect on intestinal bacilli.

Exposure to wild rosemary phytoncides of cloth materials infected with cultures of pathogenic bacteria affected a sharp reduction in the latter, in some instances to the point of complete sterilization. The antimicrobial potency of wild rosemary phytoncides was greater than that of Siberian fir phytoncides.

Tests were made to check the ability of rosemary phytoncides to disinfect relatively large volumes of air contaminated with massive doses of pathogenic bacteria. A finely dispersed microbial aerosol of hemolytic streptococci and whooping cough rods was created inside a 400 liter glass box which contained 100 g of crushed leaves and stem tops of wild rosemary. Natural reduction in the bacterial aerosol as the result of sedimentation was determined by control test and taken into consideration in the final interpretation of the results. Parallel air samples from the phytoncide-containing box were taken at given intervals and counts made after proper inoculation and incubation. The results showed that the number of viable pathogenic bacteria rapidly and sharply decreased in the phytoncide-containing box as compared with the control, in a steadily progressive manner, until the air was completely sterilized. The number of viable pathogenic bacteria in the control box air also decreased steadily, but at a much lower rate. Results of special experiments showed that the effects were bactericidal and not bacteriostatic.

In addition to volatile constituents possessing bactericidal action, the wild rosemary also contained non-volatile water-soluble substances which arrested bacterial growth. The diphtheria and whooping cough bacilli, Staph. aureus and Bact. mycoides were especially sensitive to the effects of such water soluble substances. Aqueous extracts from rosemary leaves sterilized in an autoclave were tested by the "trickling drop" method; the results showed that they contained weak antimicrobial action. The effects of fir and wild

rosemary phytoncides on the microflora of the air were tested in creches. The results indicated that phytoncides had a quantitative and qualitative effect on the air bacterial content. The number of hemolytic streptococci was reduced to an average of 10%. On the other hand, the number of mold spores suspended in the air rose considerably when fir needles or rosemary leaves were introduced into the room. Control observations of changes in the air flora of day nurseries after thorough airing showed that ventilation caused a marked decrease in the number of bacteria, but not to the same extent as did volatile fir phytoncides. Ventilation had no effect on the qualitative composition of the air flora.

The microfloral air composition changed less under the effect of phytoncides than by chemical disinfectants. However, the destruction of potentially pathogenic bacteria by volatile phytoncides, as a rule, attained hygienically significant proportions. The (theoretical) usefulness of plant bactericides as disinfectants appeared particularly impressive due to the absence of side effects on the children. On the other hand their practical application was complicated by seasonal variations in activity and the difficulty of dose standardization. Therefore, attempts should be made to obtain active plant preparations of high stability during storage, capable of being measured out in given doses and usable at any time of the year.

Such tests were made with several samples of a substance obtained from balsam fir, kindly offered to us by P. A. Yakimov and his associates, and an alcoholic extract from fir bark. Tests were made in two ways: first, their disinfectant action was tested on materials infected with different pathogenic bacteria placed in a glass box; secondly, tests were made for their effectiveness as room air disinfectants. Results of a thorough and critical evaluation of the data, indicated that only one of the 7 species of balsam fir emulsions (No. 5) manifested complete regularity in its bactericidal effect on the causative agents of children's airborne infections. Materials infected with diphtheria and whooping cough rods and with Staph. albus were rendered completely sterile; in the case of hemolytic streptococcus and Staph. aureus there was only a 3.7 to 5 fold reduction in the number of bacteria.

Results of experiments with 96% alcoholic extract of fir bark must be evaluated cautiously because of complicating effect of the alcohol and other factors. It was observed that the extract had a sterilizing effect on the diphtheria and

whooping cough rods, that it was weak in disinfecting objects infected with hemolytic streptococcus, and that it had no effect on Staph. aureus or Staph. albus.

A second series of experiments with stable phytoncide preparations was conducted in different work areas to determine their effect on the usual air microflora. Results showed that there was a marked decrease in the number of microbes after dispersion in the air of balsam fir. This decrease could not be attributable to sedimentation since throughout the experiments employees and others continued to work and move about in the rooms as usual. Statistically the number of observations may not have been sufficient; nevertheless, they served to confirm the regular effect of preparation No. 5, previously studied.

Tests were made to investigate the effectiveness of these preparations in purifying the air of a 400-liter box infected with hemolytic streptococci and the causative agents of diphtheria and whooping cough by means of a special atomizer. The results were gratifyingly positive. Results of control experiments unmistakably showed that the reduction in the number of viable microbes was caused by the bacteriocidal and not by the bacteriostatic effects of the phytoncides.

It was established that several fir phytoncide preparations which differed considerably in degree of stability, possessed noteworthy lethal effects on the bacteria which caused children's infections. Under certain circumstances such preparations can also be used to disinfect the air.

Attempts will be made to secure more potent bactericidal substances of plant origin which could be standardized.

The Effect of Mixed Industrial Dust on the Organism.

By

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Gigiena i Sanitariya, No. 11, 26-29, 1954.

Many branches of our national economy, such as coal and ore mining, chemical manufacture, machine-building, etc., include in their operations processes which generate mixed dust; heterogeneous dust generated in mining polymetallic ores is one such example. Of greatest hygienic importance are mixed dusts which contain silicon dioxide, as their basic component or as admixtures. Quartzite mining generates dust containing silicon dioxide, aluminum, iron oxides, magnesium and calcium; iron ore mining generates dust containing iron compounds, silicon dioxides, aluminum oxides, manganese, phosphorus, etc. Processes and operations in which the generated dust is of a homogenous chemical content are less numerous; examples of which are sugar, flour and sand-blast dusts.

Soviet scientists made considerable advances in the study of the etiology and pathogenesis of dust diseases. P. P. Dvizhkov, E. N. Gorodenskaya, M. G. Ivanova, I. S. Ostrovskaya, M. K. Dalem, R. V. Borisenkova, N. P. Tikhomirova, and others studied the etiology and pathogenesis of silicon dioxide, aluminum, apatite, alloy dusts, etc. However, the pathogenic significance of admixtures other than the basic components remains undefined. Only an occasional report is found in the literature which deals with the biological effect of mixed industrial dust. Such reports are mostly the result of clinical observations; only a few are based on experimental research (P. P. Dvizhkov and E. I. Vorontsova).

The experimental and clinical studies of I. M. Peisakhovich, M. M. Vilen-skii, M. M. Sheinin, E. S. Gottlieb, N. A. Padkaminskii indicated that the gradual silicosis development caused by dust containing silicon dioxide and iron could be due to the physiologically inhibitory effect iron had on quartz. I. M. Peisakhovich, A. V. Walter, F. Kettle and others believed that the presence of coal dust prevented the development of acute silicosis. On the other hand, Nozlund in his experiments with guinea pigs and rabbits showed that admixtures

of coal and lime failed to counteract the effect of quartz; admixtures of iron, magnesia and aluminum lowered the effect of quartz, while the presence of alkalies enhanced the pathogenic effect of silicon dioxide. MacDonald and Resing had seen cases of developing acute silicosis in workers who were exposed to the effect of quartz dust containing an admixture of alkalies. Nikol was of the opinion that the effect of silicon dioxide was enhanced by an admixture of fluorospar. D. Yu. Zhbarskaya in her experiments with animals obtained pathologic changes characteristic of silicosis, by exposing them to the inhalation of dust containing 38% of manganese and 62% of silicon.

Reports which deal with the possible combined action of mixed dusts are limited, and the results are at variance. Knowledge of the combined action of mixed dust is essential for the determination of hygienic limits of allowable dust concentration in the air, and for the rational selection of means for the protection of sanitary working conditions in mixed dust generating industries. With the above purpose in mind plans were made to conduct supplemental studies. Mixed dust containing quartz and hematite (ferric oxide), quartz and fluorite, quartz and coal, and quartz and chalk were investigated. Chalk dust was used as bulk material in the preparation of mixed dust samples of uniform component ratios. Each dust mixture consisted of 50% quartz and 50% admixture. The mixtures were prepared by pulverizing natural minerals to a degree of dispersion at which 96% of dust particles measured up to 4 μ . White rats were used in the tests, the dust mixtures were introduced intratracheally in 4 series of tests. Animals were kept under observation 6 - 8 months. Weights of animals were recorded at regular time intervals. It was noted that test animals gain in weight was slightly below that of the control animals; this was particularly true of the animals which were injected with the quartz-fluorite dust mixture.

At the end of the experiment the rats were sacrificed and their internal organs were fixed in 10% formalin. Histologic examinations showed the following results:

First test series. A single intratracheal introduction of 50 mg of quartz and chalk dust produced lung changes characteristic of experimental silicosis. Six months after the dust was introduced numerous nodules of different sizes developed in the pulmonary parenchyma and around the small bronchi and vessels, indicating a development of a chronic pathological process. Epithelial cells were seen in the center of the nodules and along the periphery there were

fibroblasts which separated the nodules from the surrounding tissue. The nodules were permeated by connective tissue fibers, the distribution of which followed no particular order. Large nodules were poor in cellular elements and showed signs of necrobiotic changes. In lungs of rats killed 8 months after the treatment, the silicotic nodules were larger, irregular in shape and coalesced, manifesting symptoms of sclerosis and hyalinosi. Necrobiotic changes in these nodules were considerably more pronounced, some showing the presence of necrobiotic nuclei. The histologic picture also showed the presence of non-nodular diffuse sclerosis of the pulmonary tissue and focal emphysema. The bronchi showed signs of beginning destructive changes, the muscle layer of their walls was gradually replaced by connective tissue. There were signs of developing perivascular and peribronchial sclerosis. A light pigmentation was seen in the peribronchial hyperplastic lymphatic follicles.

Second test series was intended for the clarification of effect of coal dust admixture on the action of quartz dust. Results of this series of investigations indicated that lung changes were much less pronounced than in animals of the first test series, despite the fact that the quantity of quartz introduced into the lungs was the same in both series.

Six months after the quartz-coal dust was introduced into the rats' lungs a thickening of interalveolar septi was noted which was due to their having been infiltrated by round and histiocyte cells. Sections with thickened septi and emphysematous sections alternated in the lung parenchyma; around the small bronchi and vessels there developed nodules of the lymphoid histiocyte cells with fibroblasts scattered along the periphery. Sclerotic changes in the nodules were only faintly expressed, and there was a slight hyperplasia of the peribronchial lymphatic follicles. Occasionally dark pigmented clumps were seen in the septi and in the nodules outside the cells and less frequently inside the cells. Comparison of the histologic changes in the lungs of animals 6 and 8 months after dust injection indicated that the slight increase of connective tissue in peribronchial tissue was the only pathological change observed. The results lead to the conclusion that the coal dust admixture decreased the pathogenic action of silicon dioxide to some extent, judged by the fact that the nodular and intermediate sclerosis formed in the lungs were less pronounced.

Third test series. Introduction into the lungs of the quartz-hematite dust mixture developed changes which differed in character and intensity from those observed in the first test series. The changes were practically limited

to the development of lymphoid nodules, thickening of interalveolar septi and vascular changes in the form of capillary stasis, perivascular edemas, swelling of walls of blood vessels and lymphoid cell infiltration.

The above data indicate that the character and intensity of the lung changes resembled the lung changes noted in the animals of the second group; however, the changes developed were less pronounced than in the first test series, pointing to the fact that hematite lowered the intensity of the pathogenic effect of silicon dioxide.

Fourth test series was conducted to obtain knowledge of the effect of fluorite on the pathogenic action of quartz dust. The simultaneous injection of fluorite and quartz dust elicited changes in the form of grave affection of bronchi, sclerosis of the peribronchial lymphatic apparatus, changes in the vascular system (sclerosis of walls of small arteries and periarterial sclerosis). A sharply pronounced growth of intermediate tissue, followed by sclerosis and emphysema, was noted in some animals. The histopathologic examination of one rat of series No. 4 is presented below:

Rat No. 12, weight 360 g. April 11, 1952, 50 mg of quartz and fluorite were introduced into the trachea. The animal was sacrificed December 11, 1952.

Microscopic lung analysis. Partial and in some cases complete destruction of the mucous membrane and of the bronchial walls. Acute hyperplasia of peribronchial lymphatic follicles with coarse collagen fibers visible after staining with picrofuchsin; also symptoms of beginning hyalinosis. In some large peribronchial lymphatic follicles isolated nodules with distinct outlines with signs of fibroblast reaction along the periphery were seen in some large peribronchial lymphatic follicles. Bronchial deformation with destruction of the basal membrane, coarse sclerosis of the bronchial wall, and occasional sections with pronounced thickening of the septi and an increase in the number of connective tissue fibers. The small bronchi and vessels were surrounded by small lymphoid nodules containing light refracting pigmentation granules. There were signs of sclerosis of the small arterial walls and of periarterial sclerosis. The lymphatic vessels were dilated and filled to overflowing with lymph.

The above histopathologic picture leads to the assumption that quartz-fluorite dust mixture produced a graver pathogenic effect than in the quartz-coal or quartz-hematite dust mixtures. It seems difficult to formulate a

comparative evaluation of the action of quartz-fluorite and quartz-chalk dust mixtures on the basis of the test series. It can only be said that fluorite dust in no way modified the original quartz dust effect. Obviously, the changes caused by the fluorite-quartz mixture differed in character from the changes brought about by silica.

Conclusions.

1. Results of the experimental investigation confirm the difference in effect produced by quartz-containing dust depending upon the component added to the silicon dioxide. It was shown that: a) dust mixtures containing 50% of silicon dioxide and 50% of coal or hematite (ferric oxide dust) had a less pronounced pathogenic effect than the same percentage of silicon dioxide alone; b) fluorite admixture did not lower the effect of silicon dioxide but changed its character; this may be regarded as due to an added increase in pathogenic effect of such a mixture of dusts.

2. In making hygienic evaluations of an industrial dust for the purpose of determining the limit of its allowable concentration in the air consideration should be given to the physical and chemical properties of its primary and secondary components. It was shown that differences in the chemical nature of the primary and secondary dust components may necessitate a change in the limit of allowable dust concentration arrived at on the basis of the primary component alone.

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Investigation of Air Dustiness in Agriculture.

By

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Gigiena i Sanitariya, No. 11, 48-49, 1954.

Extensive work is being conducted in the U.S.S.R. in the field of labor hygiene and industrial and agricultural mechanization. Despite that, important labor hygiene problems of an industrial and agricultural character remain unsolved. The problem of control of dust arising during work with tractors and other agricultural machines is still in the study stage. Investigation of air dustiness in agricultural field work presents the difficulty connected with the very motion of the agricultural machines. Only few references were found in the literature related to methods of air dust investigation under agricultural field conditions. In reports on the study of labor conditions in agriculture published by Neustadt, Grodzenskii, Reznikov, Kuznetsova, Veger, Neumolotova, Artem'eva, Berne, Kollarov, Bogushevskii, Kogan, Demidova, Pochtareva, and others quantitative indexes of dustiness are either lacking or they were determined by the count method; the authors described no methods for the gravimetric study of air dust concentration.

The present authors undertook to develop methods for collecting air samples for dust concentration determination under agricultural field conditions. In the development of such a method the six-volt automotive battery was used the leads of which were connected with an electric motor taken from GAZ-42 automobile which operated an air blower (fan) built by the Gor'kii Institute of Hygiene and Occupational Diseases. The installation was assembled in a special wooden box divided into sections by a cross-partition. The electric motor and air blower were housed in the upper part, and the battery in the lower section.

The air intake pipe from the air blower was connected through a flowmeter to the dust retaining adapter.

Tests indicated that the maximum rate of air flow with such an installation was 50 - 70 li per minute. Properly charged the battery provided power for four hours' work; a single ordinary charge of the battery supplied enough power for the collection of 20 or more air samples of 500 - 600 li.

The entire apparatus can be securely installed in the tractor's cabin with the dust collecting adapter fastened at the level of worker's breathing.

Samples were collected when the tractor, with the plow, harrow, etc. attached to it, was in motion. By this method it was possible to investigate the degree of air dustiness at any desired place and with different agricultural workers operating different agricultural machines.

The same method was used in studying the degree of dustiness in the air inhaled by the operators of cotton-picking machinery (Pochtareva).

The described procedure for the determination of the degree of air dustiness during agricultural work processes, could also be used in the general dust study of atmospheric air, stationary or in motion, and of mine air.

Dustiness and Meteorological Conditions in Seed Houses and in Some Sections of Cottonseed Oil Mills.

By

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From the Uzbek Scientific-Research Sanitary Institute.

Gigiena i Sanitariya, No. 11, p. 43, 1955.

Only scanty reports were found in the literature dealing with the problem of labor hygiene in the cottonseed oil industry in general, and in particular in the seed houses, in the gin rooms, the cleaning and hulling sections, and in the cottonseed grinding rooms. The present study which covered 1953 - 1954 deals with the meteorological conditions in 4 factories and 5 production departments.

In the seed house of a cottonseed oil mill air dustiness ranged between 30.6 and 154 mg/m³, depending on the cottonseed variety. During transportation and unloading of first quality seeds the dustiness was considerably lower than when low grade seeds were processed. Air dustiness during the unloading of seeds from railroad cars and during their transportation from the cotton mills

was higher than during the seed storing. The meteorological conditions were usually similar to those of the outdoor air, since the cottonseed processing took place in the open air. In the cotton fiber room, the seed meal room, the cleaning and hulling sections, the average air dustiness varied between 101.4 and 290.5 mg/m³ when the low grade cotton varieties were processed. The cleaning of first quality cottonseeds produced an air dustiness which ranged between 31.4 - 68.4 mg/m³.

The dust in the seed house, fiber room and the cottonseed meal section was of plant and mineral origin. It consisted of 82.6% organic matter and 17.4% inorganic matter, mostly wind blown silt. The degree of dust dispersion was as follows: from 1 to 5 μ - 25.4%, from 5 to 10 μ - 26.6%, from 10 to 50 μ - 30.1%, above 50 μ - 17.9%. The inorganic dust in the above sections of the plant contained total silicon dioxide which fluctuated between 43 and 15%, and free silicon between 15 and 18%, depending upon the composition of the soil on which the cotton was grown. The dust in the huller-separator room was predominantly of plant origin and consisted of 90% organic and 4% inorganic matter. Morphologically they were short fat-coated fibers. Analysis of the dust showed that it consisted of 3% ash, 4% protein, 51% cellulose, 40% nitrogen free extractives and 2% oil.

The dust in the seed house, the fiber room, grinding, cleaning and huller-separator sections contained 0.3 - 0.5% of gossypol, which, taken in large quantities with the food, proved toxic to animals and humans. Mature cottonseeds contain 0.15 - 1.9%, heat processed seeds - 0.01 - 0.9%, oil cakes up to 0.15%, crude cottonseed oil - 0.1%, purified cottonseed oil up to 0.01% of gossypol. The maximum permissible concentration of gossypol for purified oil is 0.01%. The dust also contained mold spores which could cause mycotic diseases in persons working in such sections of a cottonseed oil mill.

The temperature in the seed grinding and cleaning section differed only slightly from the outdoor temperature, and the relative humidity was somewhat higher. In the fiber room the air temperature in the summer reached 35°, while the relative humidity was comparatively normal. In the huller-separator section the temperature and the humidity of the air was higher than in the fiber room and depended on the effect of the adjacent oil-pressing section, where the temperature and the relative humidity were high.

Dust Concentration in Residential Districts of Asbest City and Its Effect on the Children's Health.

By

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Gigiena i Sanitariya, Vol. 23, No. 11, 9-12, 1958.

Prevention of asbestosis among the workers of asbestos plants is among the most outstanding problems of the Sverdlovsk Region Public Health Service. Ventilation of the asbestos work rooms is the most important of the prophylactic sanitary measures; unfortunately, as practiced at present, it results in the discharge of great quantities of asbestos dust and fibers into the atmospheric air. This made imperative the determination of the rate of air pollution in the residential districts of the city of Asbest, which is the site of many asbestos processing plants. The investigations were conducted during the winter and summer of 1950. Samples were collected by aspiration on the lee side of the pollution source, at different distances from it. The results presented in Table 1 are self-explanatory.

T A B L E 1.

**Maximal single dust concentrations in the air in mg/m^3 at
different distances from the plant.**

Plant No.	Distance from the plant					
	0.5 km		1.0 - 1.5 km		3 km	
	Dust concentration					
	Aver- age	Variation range	Aver- age	Variation range	Aver- age	Variation range
Plant No. 1	23.4	34.7 - 12.4	18.9	33.4 - 7.2	-	-
Plant No. 2	14.3	23.3 - 6.4	13.0	24.0 - 3.2	-	-
Plant No. 3	18.0	33.0 - 10.0	11.4	17.8 - 3.2	4	6.4 - 1.6

The investigation showed that the plant-emitted asbestos dust was the primary cause of a sharply delineated air pollution area surrounding the plant within a radius of 3 km. The lowest asbestos concentration ranged between 3.2

and 7.2 mg/m^3 , which is in considerable excess of the permissible limits. Highest dust concentrations were found within a radius of 1.5 km from the plant. Sedimentation chambers were the only air purifying equipment found in operation in the plants. Under such conditions it was not difficult to demonstrate that the asbestos particles of highest dispersion were the ones emitted into the atmospheric air.

Particles measuring approximately 1μ constituted 45.5 - 52.4% of the emitted asbestos dust; particles of $1 - 5 \mu$ diameter ranged between 31.4 and 39.3%; $5 - 10 \mu$ ranged between 9.2 and 18.2%, and particles of over 10μ in diameter ranged between 1.2 and 1.7%.

It is known that asbestos dust is highly deleterious to the respiratory system and that it causes pulmonary asbestosis. The high level of air pollution of the residential sections of Asbest city and the data found in the literature on the effect of asbestos dust on the health of workers in the asbestos industries prompted these authors to undertake the study of the effect of asbestos dust on the health of the population of Asbest. The effect of asbestos dust on the health of the children of Asbest city was studied first, since it eliminated the complicating factors of indoor exposure under working conditions. Under investigation were children whose residences were located in close proximity to the asbestos plants, where the concentration of asbestos dust air pollution was heaviest. Information was also gathered pertaining to the family income and general home conditions of the children. It soon became apparent that families of workers who resided closest to the asbestos plants, where the air pollution was heaviest, had lower incomes and lived under more congested conditions. (This, despite the fact that the credo and slogan of those who claim to be communists states: From each according to his ability, to each according to his needs. B.S.L.). The people living in the poorer areas constantly complained of dust in the air which made normal breathing difficult, and living quarters ventilation impossible. The worker residents preferred to leave the storm windows in, even in the summer as a protection against the permeating dust. Clinical examination of the children over the period of 1947 - 1950 showed a high percentage of respiratory diseases; such diseases occurred at high frequency also among the children who resided in the more favorable districts of Asbest city.

The data accumulated during the early stage of the investigation pointed to the need of more thorough examinations of children living in city sections

of high air dust pollution. This was accomplished in 1952 - 1953 by the members of the Sverdlovsk Medical Institute. Children were examined thoroughly - anthropometrically, spirometrically and fluoroscopically. Records were made of duration of residence in the area, of previous diseases and of other pertinent facts of life. The medical examination covered 1,340 children 7 to 14 years of age; 672 of these children came from areas of intense air dust pollution and 668 from less air polluted areas. Table 2 presents the age distribution of the children.

TABLE 2.

**Age distribution of
examined children.**

Age	Air dust concentration	
	Dusty	Less dusty
7 years	78	85
8 years	76	63
9 years	83	96
10 years	132	54
11 years	67	81
12 years	77	92
13 years	90	100
14 years	69	97

71.5% of children from the dustier areas resided there for more than 5 years. The anamnesis of these children showed that 17.3% of those children were ill with pneumonia in the past, children with such diseases constituted only 9.3% in the less dusty areas. In the more dusty areas there were twice as many complaints of cough, dyspnea, extreme fatigue and headaches. Results of spirometric examinations are shown in Table 3. Results of spirometric tests of children younger than 11 years were not recorded in this Table for lack of sufficient reliability. Results of fluoroscopic examinations showed no deviations from the age norm. There were no changes in the skin or in the tendon reflexes, and none in the skeletal or joint systems.

TABLE 3.

Vital (lung) capacity in ml of examined children.

Age	Dust concentration of region			
	Dusty		Less dusty	
	Boys	Girls	Boys	Girls
11 years	1,830	1,788	2,170	1,840
12 years	2,023	1,820	2,170	2,050
13 years	2,355	2,070	2,340	2,076
14 years	2,325	2,290	2,640	2,469

General physical development indexes were lower in children who resided in the dustier areas. Children who resided in areas of heaviest dust concentration rarely had a normally shaped chest; asthenic and barrel-shaped chests were twice as numerous; dry rales occurred twice as frequently; lung wheezes were frequent; the muscular system showed inferior development; tonsils were enlarged; adenoids and conjunctivites made their appearance. Chest volume was below normal. No sharply defined changes characteristic of asbestosis were noted, but more children living in the dustier areas were affected with respiratory diseases as they grew older. There was some indication of the fact that more defined symptoms of asbestosis appeared at a later age.

Conclusions.

1. The air of residential districts of Asbest city was heavily polluted with dust discharged into the atmosphere by the asbestos plant.
2. The discharged asbestos dust affected unfavorably the health of the children living in the proximity of the plant.
3. Results of the investigations showed the imperative need for the immediate installation in the plant of efficient dust-catching equipment.
4. It is imperative that the practice of sending the children to summer resorts and various summer camps be adopted on the broadest scale possible.

Experimental Determination of Air Dustiness in Kiev.

By

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Gigiena i Sanitariya, Vol. 24, No. 2, 74-75, 1959.

The Community Department of the Kiev Municipal Sanitary-Epidemiological Station investigated dust content of atmospheric air since 1956. The laboratory procedures used in such investigations were those described in the 1955 temporary

methodological instructions of the U.S.S.R. Ministry of Health. Air samples were taken at three observation points located: a) in a densely populated area, the site of large industrial plants and of intensive railroad and automobile traffic (at the Railroad Station Plaza); b) in a residential section free from large industrial plants and abounding in trees and shrubs (Nekrasovskaya street, No. 8); c) in a garden and park section (Pioneer park on the slope of the Dnieper river). The air investigations were conducted by the gravimetric method (487 samples) and by the count method (977 samples). Records were kept of the air temperature, barometric pressure and of the rate and direction of air currents. The air was aspirated at the rate of 25 - 30 li/min for 1 1/2 - 2 hours to a volume of 3000 liters. Dust particles were counted microscopically at 400 magnification, using an ocular and an objective micrometer. By this method it was possible to make the counts and to determine simultaneously the size of dust particles up to 1 μ and larger in visual fields, the total area of which equalled 1 mm². The data produced by the investigation are presented in Tables 1 and 2.

T A B L E 1.

City air dustiness in mg/m³.

Observation point	No. of samples	Percent of samples containing	
		Up to 0.5 mg	Up to 1 mg or more
In front of railroad station	45	67	33
Nekrasovskaya street, No. 8	252	93	7
Pioneer park	190	94	6

T A B L E 2.

Fractional dispersion of air dust.

Observation point	Up to 1 μ in %	Up to 5 μ in %	Up to 10 μ in %	Over 10 μ in %
In front of railroad station	65	6	-	29
Nekrasovskaya street, No. 8	36	5	4	55
Pioneer park	31	8	4	57

The data presented in Table 1 show clearly that the intensity of air pollution in the Nekrasovskaya street and in the park area was not as great as at the Railroad Station Plaza, where the dust content of 33% of the air samples exceeded the single maximum norm of 0.5 mg/m^3 . The data in Table 2 show that dust particles exceeding 10μ in size prevailed in the air of the residential and park sections, while 65% of the dust particles in the air of the industrial region were of 1μ or less in diameter.

It is worthy of note that most intensive air dust pollution occurred at all tested points during the fall-winter period of the year; highest air pollution intensity was found at the Railroad Station Plaza. This can be explained by the fact that during this period many of the Kiev industrial plants operated their boilers with coal instead of gas. The effect of industrial emission on atmospheric pollution was manifested also by the 53% content of carbonaceous substances in the dust collected at the Railroad Station Plaza, where many large plants were located. The air dust from the Pioneer Park and Nekrasovskaya street sections came predominantly from the soil; it contained relatively little carbonaceous substances. The high dust intensity of city air in industrial and adjoining residential areas should impel "sanitation physicians" to exercise their rights more broadly and to make greater demands on managers of the air polluting production plants. Plans for the erection of new boiler operations should mandatorily include the installation of efficient ash catching devices.

The Organization and Methods of Fluoroscopic Examination of Workers
in Dust Generating Industries.

By

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Sovietskoe Zdravookranenie, Vol. 17, No. 7, 35-37, 1958.

The organization and procedure of mass fluorographic examination of workers and others have been studied in the past for the purpose of disclosing cases of pulmonary tuberculosis. Reports of studies of foreign and U.S.S.R. investigators such as S. A. Reinberg, K. V. Pomel'tsov, Ya. L. Shekhtman, Ya. S. Beilin, S. V. Pruzhansky, T. I. Morozova present ample proof of the above statement. As a result of the efforts of these investigators the basic procedures of mass fluoroscopic examinations have been well established. Beginners, who enter the field of prophylactic examinations by the fluoroscopic method, should benefit from the experience accumulated in the past. Preventive medical mass examinations have been used widely to detect different types of occupational diseases, especially in the case of workers in dust-producing industries, for the detection of different types of pneumoconiosis. Unfortunately the fluoroscopic method is still applied to a limited extent in preventive examination of workers in dust-generating industries; the roentgenological examinations in such cases are limited mainly to chest X-rays. As a consequence, organizational procedures applicable specifically to the fluoroscopic mass examination of workers in dust-generating industries are still in the initial stage of development. In the opinion of this author, the establishment of mass fluoroscopic examinations by Public Health organizations will find wide application in the detection of pneumoconiosis; as a contributing stimulus to this, the author herein shares his experience and ideas in the field of preventive fluoroscopic mass examinations. Forms and procedures used in mass fluoroscopic examinations in the detection of tuberculosis can be profitably used as a basic procedure to be used in fluoroscopic mass examinations for the detection of other pulmonary affections. In adopting such procedure of medical examination, the following factors should be taken into consideration:

The technic of fluoroscopy makes possible the examination of tens of thousands of workers during the year; therefore, it is not practical to estab-

lish fluorographic examination centers or clinics to serve individual mines or factories. The greater number of workers in dust-producing occupations are those who work in coal mines, metallic ore and gold mines, located at considerable distances from each other; therefore, it is suggested that special fluoroscopic centers be established and equipped with mobile high power fluoroscopic equipment. Such fluoroscopic stations can be operated by a comparatively small personnel, consisting of 1 or 2 physicians-roentgenologists, 1 X-ray technician, 2 laboratory workers and 2 statisticians; a mobile unit of this type can take care of periodic prophylactic examination of workers of an entire mining region, or of an industrial district.

The organization of such mobile units is justified by many basic considerations. First, the prophylactic examination of workers can and should be conducted directly in the mine or in the factory. This will take care of the total workers' examinations which can not be done by asking the workers to come to a stationary roentgenological center at some distant clinic. With the aid of the mobile units X-ray examinations can also be made of workers suspected of having pneumoconiosis. Second, the centralization of all pneumoconiosis detection in one center may well improve the quality of the diagnosis, provide a dependable approach to the treatment of this pathological process; it may also raise the level of X-ray examination of pneumoconiosis patients. Pneumoconiosis diagnosis, based on roentgenological evidence in many cases presents great difficulties which frequently lead to individualized interpretation of some points in the X-ray picture. In other words, different investigators arrived at different conclusions on the basis of the same X-ray picture. Third, the centralization of prophylactic examination data in the hands of one group may well lead to a more thorough scientific study without loss of time. Fourth, by the organizational procedure suggested the expensive fluorographic and X-ray equipment can be used economically to the limits of their capacities. Fifth, and final, by taking over the routine periodic prophylactic examinations, the fluorographic mobile units will relieve the clinical X-ray laboratories of their enormous time and labor consuming task of routine periodic X-ray and fluoroscopic examinations and enable them to use their time for the detection of other pathologic conditions, especially swellings of the gastro-intestinal tract. It should be stated here, in an incidental way, that fluoroscopic examinations do not require the use of X-ray films, and the time consumed in developing

them should result in considerable economy.

It is not suggested that the organization of fluoroscopic mobile units for the prophylactic examinations of workers in dust-generating occupations should be established as independent institutions, rather they should be made part of municipal and regional anti-tubercular dispensaries. Such mobile fluoroscopic units could also be advantageously attached to X-ray laboratories of hygiene and of occupational diseases, or of hospitals of which such research institutes constitute a part. In such cases the fluorographic mobile units may act as applied scientific centers, offering timely scientific as well as practical solutions in the detection and study of pneumoconiosis. Such studies under such favorable conditions should be accompanied simultaneously by clinical and usual X-ray examinations. This can be accomplished by special teams of physicians and other medical workers.

In connection with methods and procedures used in conducting fluoroscopic examinations this author is in agreement with T. I. Morozova, who stated that it was not practical in prophylactic examinations to fill in the cards of all persons for purposes of ledger registration. The cards should be used for numbering the fluorograms. Only in detected, positive cases should special cards be filled in.

In the study of a dust-borne occupational disease the knowledge of the years of work at the occupation is just as important as the roentgenological data. However, in checking the fluorogram the physician may find it impossible to establish in each case the chronology of work under dust conditions, since the search for this information in journals or other papers would unduly delay the checking of fluorograms, in some instances to such an extent that the primary purpose of mass examination and speed would be impaired. Present experience suggests that the patient's work chronology be entered in the fluorographic card which registers the number of the work team and the time showing the individual's work record. Such information should be entered alongside the number of the worker's chest X-ray. Thus, the fluorogram record will show the worker's serial number and the length of work at the dust-generating occupation. Some numbers and other data can be preprinted on the cards to hasten their filling out. The material on the preprinted record cards can be modified or amended from time to time, as need may arise.

The Effect of Combustion Method and of Fuel Type on the Content of
3.4-Benzpyrene in Smoke Gases.

By

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Gigiena i Sanitariya, Vol. 23, No. 12, 6-9, 1958.

In previous reports,¹ experimental data were presented on the occurrence of cancerogenic substances in atmospheric air pollutants and in smoke gases generated by burning different types of fuel; results of experimental check tests conducted with animals to determine the blastomogenic action of tars isolated from products of fuel burning and from atmospheric dust were also presented. The purpose of the present study was to determine the effect of different methods of fuel burning on the content of cancerogenic hydrocarbons, particularly of 3.4-benzpyrene in smoke gases².

Methods of burning hard fuel differ in different plants; the pulverized and layer bed methods are examples of fuel burning methods most commonly in practice. Hard fuel in the shape of lumps can be fed manually or by automatic stokers, and the grates can be stationary or of the conveyor type. In mechanized furnaces the fuel, fed manually or by automatic stokers, moves automatically inside the furnaces and the cinders are removed while the coal is burning. At present mechanized furnaces are comparatively rare in the U.S.S.R. In large boiler rooms of electric power and heat plants chamber furnaces are used for burning powdered coal, a method by which more complete combustion is attained. Both methods of fuel burning were investigated to determine their effect on the quantity of cancerogenic substances in smoke gases, as indicated by the content of 3.4-benzpyrene in a known weight of particulate matter discharged with the smoke. Dust samples were collected from boiler room smoke flues by an appropriate aspiration method. The collected dust samples were extracted with dichlorethane for the isolation of tarry substances, which were then tested for 3.4-benzpyrene by the spectrofluorescent method. Twenty-one samples were collected in boiler

¹ Gigiena i Sanitariya, 1953, No. 2; 1954, No. 10.

² Determination of 3.4-benzpyrene was carried out by staff members of the Physio-Chemical Laboratory of the Institute - V. L. Zore and V. I. Belozerskiy.

rooms equipped with non-mechanized furnaces, 10 in boiler rooms with mechanized furnaces, and 30 in boiler rooms using the chamber combustion and powdered fuel method of fuel burning. Determinations of 3.4-benzpyrene content in smoke gases were made in 4 boiler rooms of the first group, 3 of which burned coal from the vicinity of Moscow, and the 4th burned anthracite. Table 1 shows that 3.4-benzpyrene was present in all samples and that in nearly half the samples the content of 3.4-benzpyrene ranged from 0.005 to 0.01%.

TABLE 1.

3.4-Benzpyrene content in flue gases emitted by manually fed fire grate type of boilers.

Boiler No.	Type of fuel	No. of tests	Number of samples containing 3.4-benzpyrene in %			
			0.0	0.001	0.005	0.01
1	Lower Moscow coal	3	-	-	1	2
2	Ditto	10	-	6	3	1
3	Ditto	5	-	4	1	-
4	Anthracite	3	-	2	1	-
Totals		21	-	12	6	3

In 3 boiler rooms 3.4-benzpyrene determinations were made at fuel feeding, stirring, cinder removing, etc. The results indicated no regularity of differences in the benzpyrene content; in only one set of samples collected during the poking and cinder removing stages were the concentrations 5 - 10 times as high as at other stages of fuel burning. Investigations in boiler rooms equipped with different types of mechanized furnaces were conducted also in 4 industrial plants. Two of the boilers burned coal from the vicinity of Moscow, one burned anthracite, and one burned peat. Results listed in Table 2 show that the majority of samples from mechanized furnaces contained no 3.4-benzpyrene in the smoke gases; in the remaining samples its content was at a minimum. Investigations for cancerogenic substances in smoke gases coming from burning of powdered fuel were made in boiler rooms of electric heat and power plants during the firing stage and when the fuel burning reached the steady burning stage. Fuel oil was burned in the chamber in the first hours of the firing stage, after

which coal dust was blown into the furnace. The brief firing stage was characterized by an uneven burning and was followed by steady and even process of fuel burning. A follow-up study was made of the 3.4-benzpyrene content in smoke gases of one boiler of an electric heat plant starting with the firing through 14 days of boiler's functioning. In addition to benzpyrene content in the samples of discharged smoke gases, the percentage of tarry substances was also determined. The results are presented in Table 3.

TABLE 2.

3.4-Benzpyrene content in flue gases emitted by mechanically fed fire grate type of boilers.

Boiler No.	Type of fuel	No. of tests	Number of samples containing 3.4-benzpyrene in %			
			0.0	0.001	0.005	0.01
5	Lower Moscow coal	3	2	1	-	-
6	Ditto	2	-	1	1	-
7	Anthracite	4	3	1	-	-
8	Peat	1	1	-	-	-
Totals		10	6	3	1	-

TABLE 3.

Effect of chamber type of fuel burning on the content of tarry substances and 3.4-benzpyrene in flue gases.

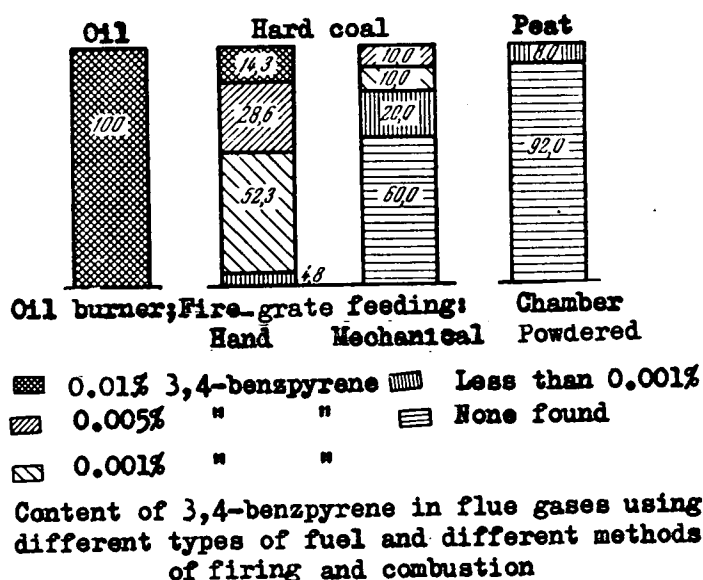
Sample taking time	Course of combustion	Tarry substances in %	3.4-benzpyrene in %
24 - 48 hours (period of coal fusing)	Unstable	0.02 - 1.1	0.001 - 0.005
7th day	Stabilized	0.02	Trace
9th day	Stabilized	0.02	Trace
11th day	Stabilized	0.00	Trace
12th day	Stabilized	0.01	Trace
13th day	Stabilized	0.00	0.00
14th day	Stabilized	0.00	0.00

The results show that the smoke gases contained tarry substances and 3.4-benzpyrene only during the firing stage; after even burning became established 3.4-benzpyrene was no more detected. Similar results were obtained in boiler rooms of several other electric power stations. The above can be re-stated as follows: 1) with regard to atmospheric air pollution with cancerogenic substances burning of powdered fuel appeared least harmful; 2) it was possible to judge the degree of fuel combustion by the content of tarry substances in the smoke emission. Both points appear clear in Table 4.

T A B L E 4.

Effect of combustion regime and of combustion chamber construction on the content of tarry substances in flue gases.

Type of fuel	Combustion regime	Type of fire chamber	Tarry substances in %
Lower Moscow coal	Layer (fuel bed)	Manual	5.0 - 5.3
Anthracite	Layer (fuel bed)	Manual	3.6
Lower Moscow coal	Layer (fuel bed)	Mechanized	1.4 - 3.4
Anthracite	Layer (fuel bed)	Mechanized	0.8 - 1.2
Lower Moscow coal	Powdered coal	Chamber type	0.0 - 0.2
Anthracite	Powdered coal	Chamber type	0.0 - 0.2



Analogous investigations in boiler rooms using oil as fuel showed that all soot samples had a high content of 3.4-benzpyrene (0.01%) and a large amount of tarry substances. The results are summarized in the form of a block diagram which indicates that the process of oil burning liberated into the atmospheric air the greatest amount of cancerogenic substances. The method of layer or bed burning in non-

mechanized furnaces produced considerably greater quantities of 3.4-benzpyrene

than in mechanized furnaces; chamber burning of powdered fuel did not produce any cancerogenic substances in smoke discharges. On the basis of the above it is recommended that boiler rooms using the bed or layer coal burning method should be equipped with mechanized furnaces; boiler rooms with non-mechanized furnaces should be replaced by central regional boiler rooms and heating centers.

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Purification of Cupola Furnace Gases Discharged into the Atmosphere.
Discussed at the Moscow City Council of National Economy.

By

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Gigiena i Sanitariya, Vol. 23, No. 11, 86-87, 1958.

The problem of rendering harmless cupola furnace gases discharged into the atmosphere was discussed at a meeting held May 26, 1958, by the Metallurgical Section of the Technical Economic Council of the Moscow City Council for Economy. Among the participants were staff members of technical and planning institutes, representatives of industrial enterprises, of the Sanitary-Epidemiological Station of the City of Moscow, and of many other organizations, including representatives of various cities in the Soviet Union.

In his report Engineer A. M. Katsnelson pointed out that modern requirements for city air purity make it mandatory that foundry operators develop measures for dust elimination and for improved gas combustion before they are emitted into the atmosphere. The question of utilizing the heat produced by the combustion process for blast furnace heating was considered at the same time. The speaker mentioned the fact that a method was found abroad for the operation

of cupola furnaces with closed charge hole and complete suction removal of waste gases which were subsequently burned in special chambers. A. M. Katsnelson stated that in January 1957, a cupola furnace was installed in the foundry shop of a machine plant which was equipped with a separate air pre-heater. The cupola furnace had provision for possible blast heating by burning waste gases and by utilizing the heat produced by burning fuel in the fire box. This furnace had an inside diameter of 400 mm and an operating height of 1700 cm which made possible the utilization of waste gas heat. The cupola furnace had two rows of tuyeres, brick lined air box, and partition zones, through which the cupola furnace gases entered the separation column, and therefrom the supplemental combustion chamber. Then by means of a flue gas pump the gases were drawn through a recuperator (recovery unit) and discharged into the atmosphere. The air was forced into the recuperator by a high pressure blower; from there is passed through a fettled air conduit into the tuyere box of the cupola furnace. The recuperator consisted of a combination of a radiation and tubular sections in one tower which permitted complete utilization of furnace gases with a temperature of 1200° .

Observations of the operation of this cupola furnace indicated that the utilization of waste gas heat made possible the attainment of high temperature blast and cast and pig iron temperatures acquired by modern foundries. At the same time it helped to solve to a considerable extent the problem of supplemental burning and purification of the gases before they were emitted into the atmosphere. Due to the above features, the content of carbon monoxide and of dust in the exhaust gases of this cupola furnace was 10 to 11 times lower than in a furnace with a cold blast. A hot blast cupola furnace is economical in the use of coke and cuts down on the amount of second grade products. Metal turnover per m^2 of furnace cross-section increased, indicating that a furnace of such construction was highly efficient in addition to having sanitary-hygienic advantages, as compared with cold blast furnaces. The gases given off during 24 hours by an ordinary cupola furnace of 15 - 16 tons p/hr production rate carry with them into the atmosphere 730 - 760 kg of dust containing 40% of coke and 1500 - 1700 kg of carbon monoxide. The above indicated ten- to elevenfold reduction in these air polluting substances constituted a considerable improvement in the conditions of the atmospheric air.

I. O. Tsypin reported on a closed cupola furnace designed and constructed

by the Central Scientific-Research Institute of Heavy Machine Building (TsNII MASH). This furnace is equipped with a suction system which forces the cupola gases through a two-step recuperator constituting a combination of a radiation and a convection recuperator; it includes a combined cyclone and scrubber dust removing system. Before the cupola furnace gases enter the convection recuperator they pass through two vertical pipe dust retainers and a supplemental combustion chamber. A cupola furnace with a 600 mm inside shaft diameter has double-level tuyere arrangement and is equipped with two outlets for removal of gases from below the grate and at same level above the furnace smelting zone. With this furnace it is possible to superheat cast or pig iron to 1500° , increase the casting productivity by 50%, lower the coke consumption and purify the furnace gases from dust and carbon monoxide. Dust removal by the cyclone amounted to 65% and by the scrubber to 95%.

The management of the Voikov Cast and Pig Iron Plant decided to install in foundry section 1 a closed type cupola furnace with a 15 - 16 ton per/hour production capacity of the Leningrad Institute "GIPROSTKLO" design; the main characteristics of this design were the complete removal of all blast furnace gases through the side outlets located under the charging platform; this permitted maximum utilization of heat produced by coke burning inside the furnace and completely eliminated the emission of dust by blast furnace gases. Waste gases taken from the cupola furnace entered the supplemental combustion chamber where, in addition to combustion, the gases were subjected to preliminary dust purification in a cyclone. Therefrom the blast furnace gases, heated to 800° , entered the convection recuperator where they preheated the blast air to 500° . After yielding most of their heat in preheating the blast air, the waste gases passed through a second convection recuperator where they preheated the intake air needed for shop ventilation; from there, now having a temperature below 250° , they passed through an electrostatic precipitator for fine purification from dust, and were then discharged into the atmosphere.

The operating characteristics of this type of cupola furnace, with blast air preheated to 500° , are an increase in the furnace productivity, a reduction in coke consumption, an increase in cast or pig iron temperature to $1430 - 1480^{\circ}$, which results in better quality metal, in addition to improved sanitary-hygienic conditions of the vicinity adjacent to the plant.

In connection with the fact that removal of waste gases in the cupola

furnace is accomplished through side outlets beside the grate, the designers introduced the following features: a special charging device which permitted air-tight closing of the cupola furnace; the bringing up of charge material into the charge compartment by a skip hoist; central blast furnace charging and automatization of all lifting and charging operations, etc.

At present the plant is testing the efficiency of Ninu recuperators, which are based on the principle of regeneration. Plans are made to utilize a recuperator of this type instead of a convection recuperator of preliminary preheating.

V. S. Mysovakiï reported on "The Principles of a Cupola Furnace Design Provided with Automatization of Controls and Regulation of the Smelting Process"; V. P. Mizikin reported on "Intensified Cupola Furnaces with Tubular Water-cooled Tension Screen, Rammed Lining and Distributed Blasting". Utilization of suggestions contained in the reports offered possibilities for higher production efficiency, improvement in the working conditions of cupola furnace operators.

It is of interest that the meeting of the Metallurgical Section of the Technical-Economic Council of the Moscow City Council of National Economy demonstrated that, while the primary purposes of the changes suggested and applied to the operation of cupola furnaces was to improve the quality and increase the rate of production of metallurgical products, they also brought about improvements in working conditions and in the sanitary-hygienic conditions of the atmospheric air and in the general living conditions in the nearby populated areas.

Industries having foundry shops should, on demand of sanitation authorities, undertake a more extensive reconstruction of cupola furnaces of medium and large production capacity. Plants with furnaces of small production capacity may not be able to rebuild their furnaces as per above suggestions, for sound reasons of economy. According to the plans of Councils of National Economy they must gradually discontinue operating and their assignments should be transferred to plants where reconstruction of furnaces has resulted in significant capacity increase, or additional new foundry plants should be built.

Street Noise Abatement by Proper Allocation of Tree and
Shrub Plantings in City Blocks.

By

P. I. Leushin and M. Ya. Nikitin.

(From the Leningrad Scientific-Research Institute of Sanitation and Hygiene).

Gigiena i Sanitariya, No. 9, 8-15, 1954.

The importance of tree and shrub planting to city planning is great and many sided; trees decorate the streets, parks and squares, absorb the air dust and gases, reduce the number of air suspended bacteria, and lower the intensity and spread of noise between city dwellings. Tree and shrub planting can also serve as a positive psycho-hygienic factor.

The sanitary hygienic importance of trees, shrubs and other green plants has been well studied and described by U.S.S.R. hygienists Adamova, Anastas'yev, Bragin, Beryushev, Fedynskii, Kharakhinov and others. However, only few reports dealt with the effect of green belts on the intensity of city noise and its reverberation from one place to another. Observations conducted in Moscow and Leningrad by Fedynskii, Alekseev, Shapshev and Leushin were mere orientations; the authors frequently came to contradictory conclusions, stating that in some instances the noise was intensified by the presence of trees, and in other cases the noise intensity was reduced. However, most reports noted the beneficial effect of green belts in decreasing city noise. None of the reports proposed any methods or green belt systems to be used in combatting city noise. Professor K. N. Shapshev in his work "Problems of City Noises and Struggle Against Them", published in Leningrad in 1939, attempted to approach the problem of planning green zones in cities with a view to combatting the street noises. He measured the intensity level of the noise in the gardens and parks of Leningrad in the summer, when the trees were in full foliage, and in the fall, after leaf shedding.

The present authors studied the noise abating effects of green plantings in the blocks of a residential area built and landscaped during the Soviet regime. The purpose of the study was to determine the best way of planting trees and shrubs in any city block to attain maximum noise abatement in the streets and yards and arresting noise penetration into apartments through the windows facing the street. The study extended over three blocks along Lesnoi

Avenue in Leningrad, which had been investigated by Professor K. N. Shapshev in 1936 with regard to noise. At that time the trees and shrubs had just been planted and they were free of foliage. At the present study the trees have grown so that their tops reached the 4th floor level, and offered the opportunity to study their effect on street noise blocking and abatement when in full foliage.

The patterns of tree and shrub planting in the three blocks are shown in Figures 1, 2 and 3. Dwellings in blocks 1 and 2 were built perimetrically; the trees were tall and the shrubs were 2 - 3 meters high; they were planted inside the block's perimeter 10 - 15 meters away from the buildings. Residences in block 3 were arranged differently as shown in Fig. 3. The tall trees were planted in the sanitary clearance zones between the dwelling rows; the main entrance to the block, at the right corner, was surrounded by a thick belt of shrubs 2.5 m high.

The intensity level of the street noise coming from Lesnoi Avenue was determined at different points of the block area. Lesnoi Avenue is an arterial transport highway along which passed street cars, buses, trucks, etc. Sound measurements were taken at 16 points for each of blocks No. 1 and 2 and at 12 points for block 3. Additional sound determinations were made at three points

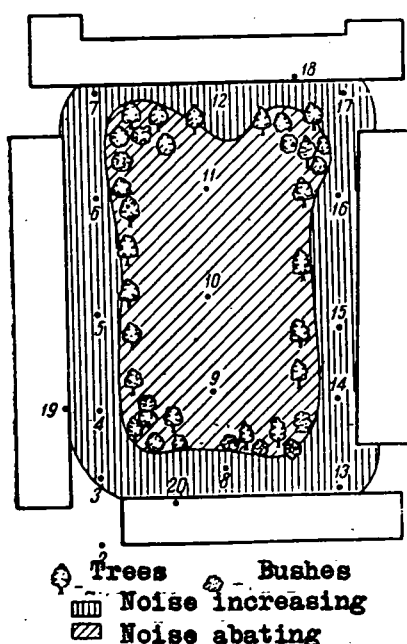


Fig. 1. Block No. 1.

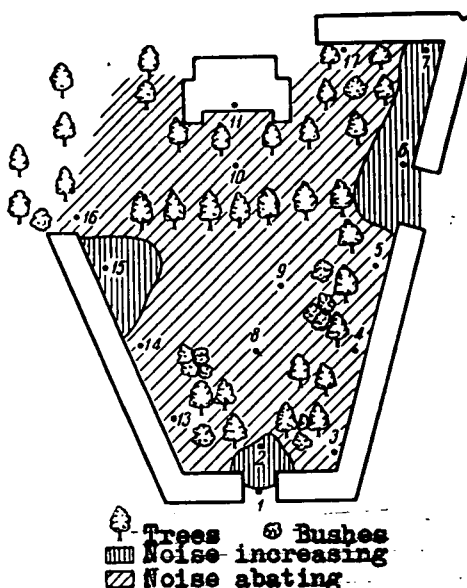


Fig. 2. Block No. 2.

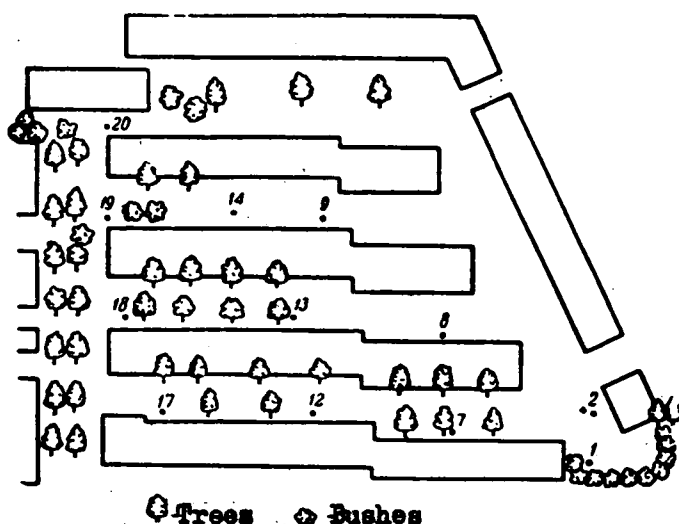


Fig. 3. Block No. 3.

at the second floor level in block 1. The noise intensity determinations consisted of 15 - 19 readings taken on the sound scale over a period of 20 minutes. The 20 minute readings were repeated when necessary to obtain a numerical value of the average noise level for a given point with an error not exceeding ± 0.3 of a phon (unit of sound). Such a high degree precision of sound intensity determination was dic-

tated by the fact that changes brought about by the green clearance rarely reached 6 - 7 phons. Unlike K. N. Shapshev, the present writers excluded the sound of automobile horns. The noise from horns (determined in front of the entrance of the block) was heard only on rare occasions in this block; in addition, automobile horn noise intensity inside the block differed somewhat from the usual noise of 50 - 60 phons caused by the wheels and exhaust of the traffic. The curves of noise intensity are inversely proportional to the distance from the point of origin, as shown by the straight line presented in Fig. 4. The points' numbers where noise measurements were taken are indicated in Fig. 1.

Curves in Fig. 4 show that the horn noise decreased considerably more than the general traffic noise, but at point 7 it increased by 3 phons as compared with point 6, owing to the reflection from the wall of the rear building. The average traffic noise decreased more evenly and had the same intensity at point 7 as at point 6. In addition, the intensity level of the noise from traffic was considerably below that from the horn. It soon became apparent that measuring of natural street noises, representing the true picture of the noise field in the block, required greater precision than measuring the noise from an artificial loud source. The results of the street noise determinations inside the three blocks are listed in the following Table.

Areas of increased and decreased noise intensity are indicated in Figs. 1 and 2 as per legends, thus illustrating the noise-abating effect of green plantings. Investigations of noise intensity at the level of man's height in block

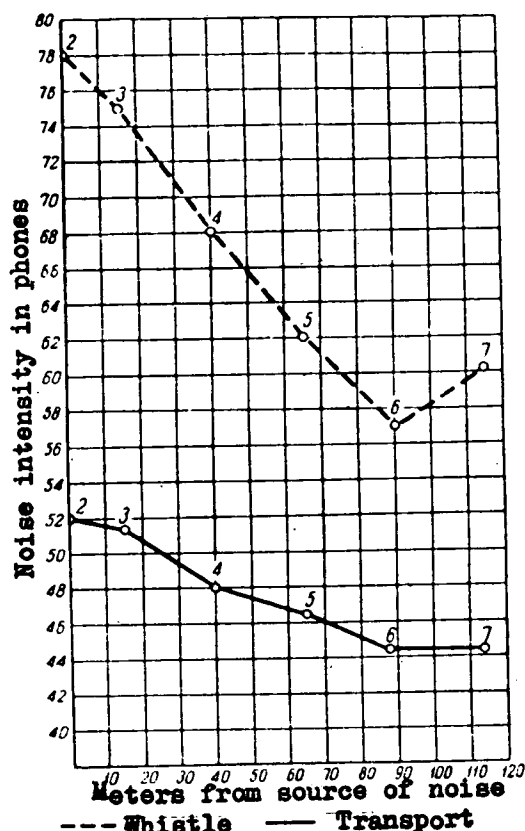


Fig. 4. Abating intensity of noise in a block built up perimetrically as the straight line distance from the source of noise increases.

1 indicated that in the summer, when the foliage is fully unfolded, the noise decreased only at 3 points located within the green belt at the center of the block. At the points inside the block, close to the building walls, the noise was louder in the presence of full foliage. This seemingly paradoxical phenomenon can be explained on the basis of the results of observations in block 2 where slightly increased noise intensity was recorded at points 2, 6, 7 and 15. All other areas in block 2, including those close to the inside walls, showed a considerable decrease in noise intensity. Thus, at points 3, 4, 5, 13 and 14, lying close to the inner walls of the buildings, noise intensity decreased by 1 - 5 phons in the summer, when foliage was fully unfolded.

In comparing the conditions under which the noise penetrated from the street into blocks 1 and 2, it can be seen that

the street noises penetrated into block No. 1 through the clearance spaces between the buildings and entered into the space between the green belt and the walls. In block No. 2 the street noises penetrated into the space surrounded by the green strip. It has been known that green tree crowns not only absorbed sound energy, but also reflected it. According to P. I. Leushin (P. I. Leushin, *The Effect of Tree Planting on the Distribution of Street Noises*, *Gigiena i Sanitariya*, 1949, No. 6) 74% of sound energy which encountered leaves was reflected by the green tree crowns. This explains why the noise near the building walls of block 1 increased when the trees were in foliage. The space between the green belt and the walls is a corridor along which noise spread without obstruction; the brick walls reflected about 97% of the noise falling upon them; the ground surface, paved with cobblestones and forming the floor of the corridor, reflected less of the noise; the third side of the corridor was a solid row of trees with wide crowns. Hence, the large concentration of sound energy

Average level of street noise in phones which penetrated into the blocks in the summer during full foliage and in the fall after foliage shedding

Point No.	Block No. 1			Block No. 2			Block No. 3				
	Noise intensity D_1 No vegetation	Noise intensity D_2 Trees, shrubs, etc	$D_1 - D_2 = \Delta$	Point No.	Noise intensity D_1 No vegetation	Noise intensity D_2 Trees, shrubs, etc	$D_1 - D_2 = \Delta$	Point No.	Noise intensity D_1 No vegetation	Noise intensity D_2 Trees, shrubs, etc	$D_1 - D_2 = \Delta$
2	52,5	52,8	-0,3	1	56,4	55,9	+0,5	1	56,1	52,4	+3,7
3	51,5	51,5	0	2	48,6	49,1	-0,5	2	48,6	45,8	+2,8
4	48,2	49,2	-1	3	43	41,8	+1,2	7	45	43,4	+1,6
5	46,6	47	-0,4	4	46,5	41,6	+4,9	8	41,6	40,6	+1
6	44,6	45,6	-1	5	44	41,9	+2,1	9	42	39,6	+2,4
7	44,4	45,9	-1,5	6	42,4	43,3	-0,9	12	44,1	37,8	+6,3
8	41,2	43	-1,8	7	38,3	38,8	-0,5	13	42	41,1	+0,9
9	43,1	43	+0,1	8	44,4	42,5	+1,9	14	42	40,2	+1,8
10	46	44,6	+1,4	9	44,1	41,6	+2,5	1	46,3	44,7	+1,6
11	45,1	44,5	+0,6	10	43	40,8	+2,2	18	45,6	43,6	+2
12	44,8	46,6	-1,8	11	43,9	41,7	+2,2	19	44,3	38,5	+5,8
13	45,1	47	-1,9	12	—	—	—	20	43,1	36,4	+6,7
14	43,5	45	-1,5	13	45,3	44,2	+1,1				
15	44,7	47,4	-2,7	14	43	42,3	+0,7				
16	45,7	47,1	-1,4	15	41,8	42,3	-0,5				
17	46,5	47,2	-0,7	16	42,9	41,9	+1				
18	46,8	46,2	+0,6	17	42,7	38,9	+3,8				
19	42,9	47,5	-4,6								
20	35,8	42,4	-6,6								

in this corridor finds its explanation. In block 2, the flowing noise directed into the space surrounded by green vegetation was absorbed to a considerable degree by multiple reflections from the green tree crowns. A small amount of noise energy penetrated into "the corridors" between the dwelling walls and the clumps of trees. The pattern of noise diffusion observed and its explanation are the chief governing aspects to be considered in planning the location of green strips between urban buildings. By taking into account the reflected and absorbed energy, it is possible to determine all other deflections from the noise diffusion caused by green tree crowns. It is to be noted that at points 19 and 20 sound measurements taken at the 2nd floor level in the summer

were louder by 5 - 7 phons, due to sound energy reflected from the tree crowns.

An examination of the pattern of noise diffusion in block No. 2, after the leaves have unfolded, showed that intensity of the street noises at point 1 remained practically unchanged, since the 0.5 phon decrease observed barely exceeded the limits of experimental error. At point 2 the noise slightly increased due to the reflection of sound waves from the tree crowns in the first row. Although the increase at this point was also 0.5 phon, its value was accepted as significant because the initial noise was slightly lower at point 1 in the summer. At points 6 and 7, where the noise entered through the clearance space between the buildings on the right, the slight increase in noise intensity in the summer can be explained by the same fact of the sound reflection from green tree crowns. The increase in noise intensity in the summer at point 15 in comparison with points 14 and 13 can be explained by the clearance space implanted with shrubs near point 15, through which sound waves penetrated from the green belt.

The results of observations on noise penetrating from Lesnoi Avenue to block 3 (see Fig. 3) show that at all points of this block there was a slight decrease in the intensity of noise caused by the trees in full foliage. The greatest decrease of about 6 phons was observed at points 12, 19 and 20. All these points were surrounded by green strips, protecting them from the direct penetration of sound waves. At points 1 and 2, outside the green belt, consisting of lilac shrubs, noise intensity decreased by 3 - 4 phons in the summer. At points 17, 18, 19 and 20, noise from Lesnoi Avenue came chiefly in the form of sound wave reflection. In the absence of foliage on the trees, the brick walls of dwellings served as the sound wave reflectors when the trees were in foliage, the leafy crowns of the trees and shrubs reflected the sound waves. The noise intensity decreased as a result of the absorption of sound waves by the foliage of the green belts. The cause of decrease in noise intensity was as follows: the effect of foliage was significantly more noticeable at points 19 and 20, which were further removed and which the sound waves reached after multiple reflections.

Some authors are of the opinion that covering the outside walls of buildings with sound-absorbing plaster or some other sound-absorbing material, such as climbing vines was a useless adaptation for the combat of street noises (S. P. Alekseyev. Investigation of Noises in Moscow, M. 1950, page 85). This opinion was based on a maximum difference between noise intensity determined

at similar distances from the source (30 m), but under different conditions, such as in an open space where the sound travel was unobstructed, and in a street with intervening 6 story buildings. The difference amounted to 10 phons. The author erroneously assumed that to decrease noise intensity by 10 phons it was necessary to cover the walls with a plaster which provided sound absorption equivalent to that of open space, that is, a sound-absorbing coefficient equal to 100%. This assumption might be correct only if the intensity of the noise in the streets was produced by direct sound waves reflected only once. Actually, however, noise created in a narrow street results from repeated reflections of sound waves superimposed on the primary ones. For this reason the effectiveness of sound absorbing plaster or of climbing vines is considerably greater than that which might follow from the

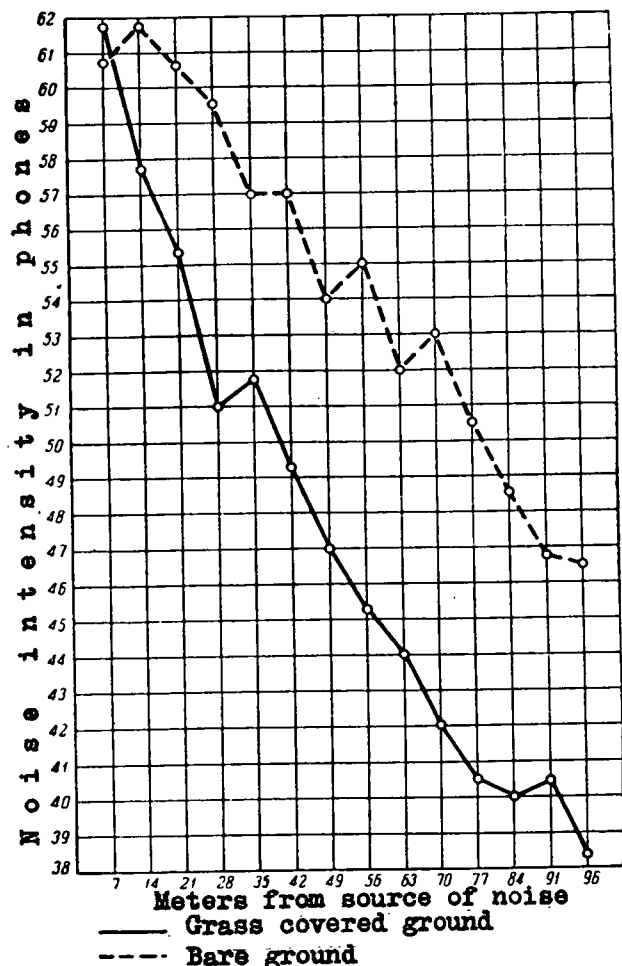


Fig. 5. Effect of grass on noise intensity at different distances from source of noise.

above reasoning. The results of our observations conducted at Mars Field in Leningrad convinced us that the position taken by the present authors was correct. The curves in Fig. 5 record the intensity of noise caused by traffic at different distances from the street-car line; determinations were made under different conditions of grass-seeded or bare soil. The results show that covering the ground with growing grass and obviating the sound-reflecting properties of only one surface decreased the noise intensity at all points by 6.3 to 7.5 phons on the average. It is also generally known that street noises decreased in intensity when there was light snow on the ground. Therefore, it seems safe to assume that climbing

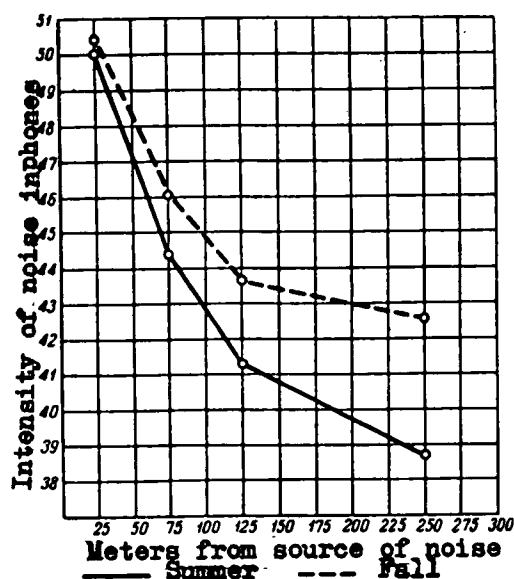


Fig. 6. Effect of trees and shrubs on noise intensity at different distances from source of noise

vines on the walls of buildings or sound-absorbing plaster covering the external surface should be effective means for street noise abating.

Figure 6 indicates that the loud traffic noise decreased in the summer and fall farther away from the main highway (Sadovaya Street) in Mikhailovskii Park where, in addition to grass, there were century old trees.

This is a report of studies of methods for planning locations of tree and shrub plantings in city blocks to absorb noise originating in the outside streets. However, a source of noise originating inside the block is

of equally significant and practical interest. To protect residential dwellings from such noise, it is recommended that trees be planted along the perimeter of the area from which the noise originated. An effective impenetrable green barrier should consist of a combination of shrubs and tall trees with heavy foliage.

Summary.

1. By proper distribution of green belts inside a city block, it is possible to maintain the noise within the limits of ± 6 phons.
2. To decrease the noise penetrating from the outer streets and to reduce their reflection from the building walls facing inside the block, it is necessary to plant the trees in such a way that sound waves which penetrate into the block would be directed towards the surrounded space.
3. A shrub barrier located between the source of noise and the enclosed area of the block is beneficially effective.
4. Wall climbing plants and ground grass covering decreased noises which penetrated into the block.

A Compendium of Official Materials Related to Problems of Sanitation
and Prophylaxis.

Supplement to Books 1 - 3 of the U.S.S.R. Ministry of Health,
State Publishers, Medical Literature, Moscow - 1955 - Medgiz.

Pages 89, 90 and 91; items 28, 29 and 30.

Item 28. - Limitations in the Use of Jalousie Ash Abaters "VTI" (All-Union Technical Institute) for the Purification of Smoke Gases from Ash.

A circular (letter) issued by the Main State Sanitary Inspection of the U.S.S.R. Ministry of Health, March 27, 1953, and coded 128-53.

Jalousie ash abaters of the VTI design have been adopted recently by boiler-operated plants and electric heat and power stations for the purification of smoke gases from ash. Authorities of the State Planning organizations included this type of jalousie ash abaters in their plans of industrial building construction on the basis of questionable recommendations; their choice of this type of purifier in preference to battery cyclones, cyclones and electrostatic precipitators appears to have been motivated primarily by the fact that the VTI jalousie ash abater was of smaller dimensions and its construction and installation were more economical. By now evidence has accumulated which shows convincingly that most of the VTI jalousie ash abaters operated at low efficiency and, hence, the degree of smoke purification from fly ash left much to be desired. The information now in possession of the various organizations of the All-Union State Sanitary Inspection and the results of investigations carried out by the Institute Giprogazo-otchistka and by the Institute NIIOGAZ and by Trust Gazo-otchistka accumulated during their 1949 - 1952 studies of the operation of jalousie type of ash abaters can be summarized in the following conclusions.

1. In the case of burning powdered coal the residual ash content of smoke gases after having passed through jalousie ash abaters amounted to 5 - 7 g or more per nm^3 (at 0° and 760 mm mercury); this is approximately 2 - 3 times as high a residual ash content as was found in smoke gases of similar type purified by battery cyclones. Such a high pollution of atmospheric air with ashes must not be allowed. The serviceability of jalousie ash abaters in the case of smoke gases coming from powdered coal burning ranged between 6 - 10 months due to the fact that jalousie grates wore out under the impact of the ash par-

ticles; as compared with this battery cyclones, for instance, have approximately five times as long a period of serviceability.

2. In layer bed combustion of coal the residual content of ash in smoke gases after purification with jalousie ash abaters amounted to $1 - 2 \text{ g/nm}^3$, when lower Moscow coal was burned, which is 3 - 5 times as high a residual ash content as was found after smoke gas purification with a battery cyclone or cyclone of NIIOGAZ design (NIIOGAZ--Nauchno-Issledovatel'skii Institute Otchistki Gaza, or Scientific-Research Institute of Gas Purification).

3. In burning lump or milled (cut) peat the residual content of ash in jalousie ash abaters amounted to $1 - 2.5 \text{ g/nm}^3$ of the smoke gas.

Attention should be called to the fact that the efficiency of jalousie type of gas purifiers is greatly affected by changes in the volume of gas passed through per unit time. Deviations above or below the rate of gas passage for which the jalousie purifier was designed greatly reduce its efficiency, and under normal practical conditions such deviations occur frequently. The jalousie apparatus manifested the tendency to frequent clogging by ash, which constitutes another factor leading to considerable drop in performance efficiency; the need to frequently clean the jalousie gas purifiers hinders its convenient utilization in practice.

In view of the above the All-Union State Sanitary Inspection offers the following suggestions to industrial administrators and to industrial planning organizations:

a) In boiler operated plants and in electric heat and power stations, which burn powdered coal, the installation of jalousie apparatus for the purification of smoke gases is not recommended. Built in jalousie ash abaters are mere technical adaptations for the sole purpose of protecting the tail surfaces of the heat unit, of the economizers, the air preheaters, etc. It is, therefore, recommended that in making plans for the purification of smoke gases no provision should be made for the installation of jalousie ash abaters.

b) In boiler units which burn coal in layers over fire grates jalousie ash abaters may be installed where the coal consumption is not in excess of 5 tons per hour and only in such plants which are located favorably in so far as sanitary-hygienic conditions are concerned, i.e., plants which are surrounded by adequate sanitary clearance zones, or plants which are located in regions where the sanitary-hygienic requirements are not too high. In all other in-

stances it is imperative that ash abating installations be of high efficiency, such, for instance, as cyclones of the NIIOGAZ design or battery cyclones.

c) Boiler-operated plants and heat and power electric centers which burn lump or cut (milled) peat may resort to the use of jalousie ash abatements pending special instructions and regardless of the rate of fuel consumption.

Item 29. - The Use of Ash-Removing Apparatuses "Cyclone LIOT with Water Film" for the Purification of Ventilation Air.

Circular (letter) issued by the All-Union State Inspection, March 27, 1953 as code No. 127-53.

The All-Union Scientific-Research Institute of Labor Protection VTsSPS in Leningrad (LIOT-Leningradski Institut Okhrany Truda) designed a dust separating apparatus trade-named "Tsiklon Liot with a Water Film". In its design this apparatus is a vertical cylinder made of steel sheeting. A continuous film of water runs down its inner surface; the water comes from a series of water outlets arranged at the uppermost part of the cylinder. The dust-laden air enters the cylinder at right angles to the axis of the cylinder from an inflow pipe attached tangentially to the cylinder; after having been purified, the air exits at the upper part of the cylinder from an outflow pipe similarly attached to the cylinder. Upon entering the cylinder the air is given a rotating motion. The separated dust drops down into a conical bin attached to the lower part of the main cylinder, wherefrom it is removed through a specially provided opening attachment.

It can be readily seen that the basic principle of this dust remover is that of a cyclone type of separator the efficiency of which is considerably enhanced by the continuous water film. In the usual dry cyclones the final removal of the separated dust is accomplished in the lower end of the cone via a special opening which forces the dust into a special bin or bunker. Thus, in the dry cyclone the dust particles thrown against the inner wall of the cylinder by the centrifugal force upon the entrance of the dust-laden air into the cylinder continue to stay within the cyclone as components of the total whirling mass. In the water film cyclone (wet cyclone) the dust particles thrown against the inner surface of the cylinder wall by the centrifugal force are immediately taken out of the whirling air by the downflowing water film. This, then, is the essential difference between the dry and wet (water film)

cyclone types of dust separators. The separated dust particles in the water film cyclone can not be torn away from the surface of the cyclone and, hence, can not re-enter the general whirling mass of air or gas; once separated from the dust-laden air the dust particles can not be carried out into the atmospheric air, hence the greater purifying efficiency of the "Cyclone LIOT with Water Film".

The Institute designed six sizes of this type of cyclone with capacities ranging between 1200 and 10,000 m³/hour of air. Where greater air purifying capacity is required, several such cyclones can be installed in parallel series. Another advantage of the "Water-Film LIOT Cyclone" is its ease and simplicity of construction; any well supplied equipment building plant or shop can construct it.

Cyclones LIOT with Water Film can be recommended for the purification of aspiration and ventilation air from dust wherever wet type of air purifiers can be installed. It is not recommended for the removal of adhesive or cementing type of dust. It is recommended that air with a dust content exceeding 2 g/m³ undergo preliminary dust purification in a dry cyclone or inertia dust abater before passing it through the Cyclone LIOT Water Film type.

The Leningrad Institute of Labor Protection (LIOT) obtained the following information (data) regarding the performance efficiency of the water film cyclone:

1. Tests were made with a two-step air purification, the first consisting of two parallel operating dry LIOT cyclones and the second of two wet film LIOT cyclones. The dust-laden air was coming from a coal grinding section and from the coal dust conveyer department of an electric heat and power station; the original dust content ranged between 1.5 - 2.0 g/m³; after the above system of purification the residual air dust ranged between 13 - 16 mg/m³.

2. Tests with foundry air dust removal by the water film LIOT cyclone gave the following results:

- a) With a gravimetric 16% content of dust particles of up to 1 cm/sec motility the degree of dust purification reached 98.7%;

- b) With a gravimetric 26% content of dust particles of similar motility the degree of dust purification was 93.4%.

3. Results of tests with sand blast dust particles were as follows:

- a) With the use of a two-step dust purification, consisting of a

dry LIOT cyclone and a water film LIOT cyclone and with a gravimetric 25% of dust particles of up to 1 cm/sec motility the degree of purification reached 99.1%;

b) With the use of a two-step dust purification, consisting of inertia dust abater and LIOT water film cyclone and with dust load as above, the degree of dust purification amounted to 99.4%.

It required 45 - 65 kg of metal to build a water film cyclone of 1000 m³/hour capacity, exclusive of the metal required for installation and a water consumption of 0.13 - 0.3 l/m³ of air. The cyclone created a pressure drop of 40 - 80 mm of water.

More detailed information concerning the LIOT cyclones can be obtained from the Scientific-Research Institute of Labor Protection, Leningrad, Gagarinskaya 3 (U.S.S.R.).

The All-Union State Sanitary Inspectorate suggests that in making provision for ventilation and aspiration installations authorities responsible for industrial production plants request of the basic planning organizations a more general resort to the use of Cyclones LIOT with Water Film for the purification from dust of air discharged into the atmosphere by industrial production and processing plants.

Item 30. - Supplement to Circular (Letter) Issued by the State Sanitary Inspectorate of the U.S.S.R., March 27, 1953 under Code No. 128-53, Regarding Limitations in the Use of Jalousie Ash Abaters VTI for the Purification of Smoke Gases from Ash. (September 7, 1954, No. 112-2/5-1002).

With reference to inquiries coming in regarding the possible application of jalousie type ash abaters to the purification of smoke gases the Main State Sanitary Inspectorate of the Ministry of Health of the U.S.S.R. offers the following clarifying comment:

In boiler operated plants which burn coal by the layer method over fire grates the use of jalousie ash abaters is permissible only where the coal consumption is not in excess of 5 tons per hour.

In exceptional cases where the boiler operated plant is located in a region where the sanitary-hygienic surroundings and other conditions are highly favorable, jalousie ash abaters may be installed for the purification of smoke gases, provided, however, that the coal consumption is not in excess of 8 - 10 tons per hour. The same applies to boiler-operated plants, the technical

facilities of which make the installation of other types of ash abaters not feasible; provided, in this case, that other strictly local supplemental correction measures can be resorted to.

In the preparation of new plans for the construction of boiler-operated industrial production and processing plants the responsible industrial operators must demand that provisions be made for the installation of ash removers of highest operating efficiency, such, for instance as cyclones NIIOGAZ, if the volume of purified gases is not expected to exceed 50,000 m³/hour, or battery cyclones, if the volume of gases to be purified is expected to be in excess of 50,000 m³/hour.