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B.S. Levine, et al.

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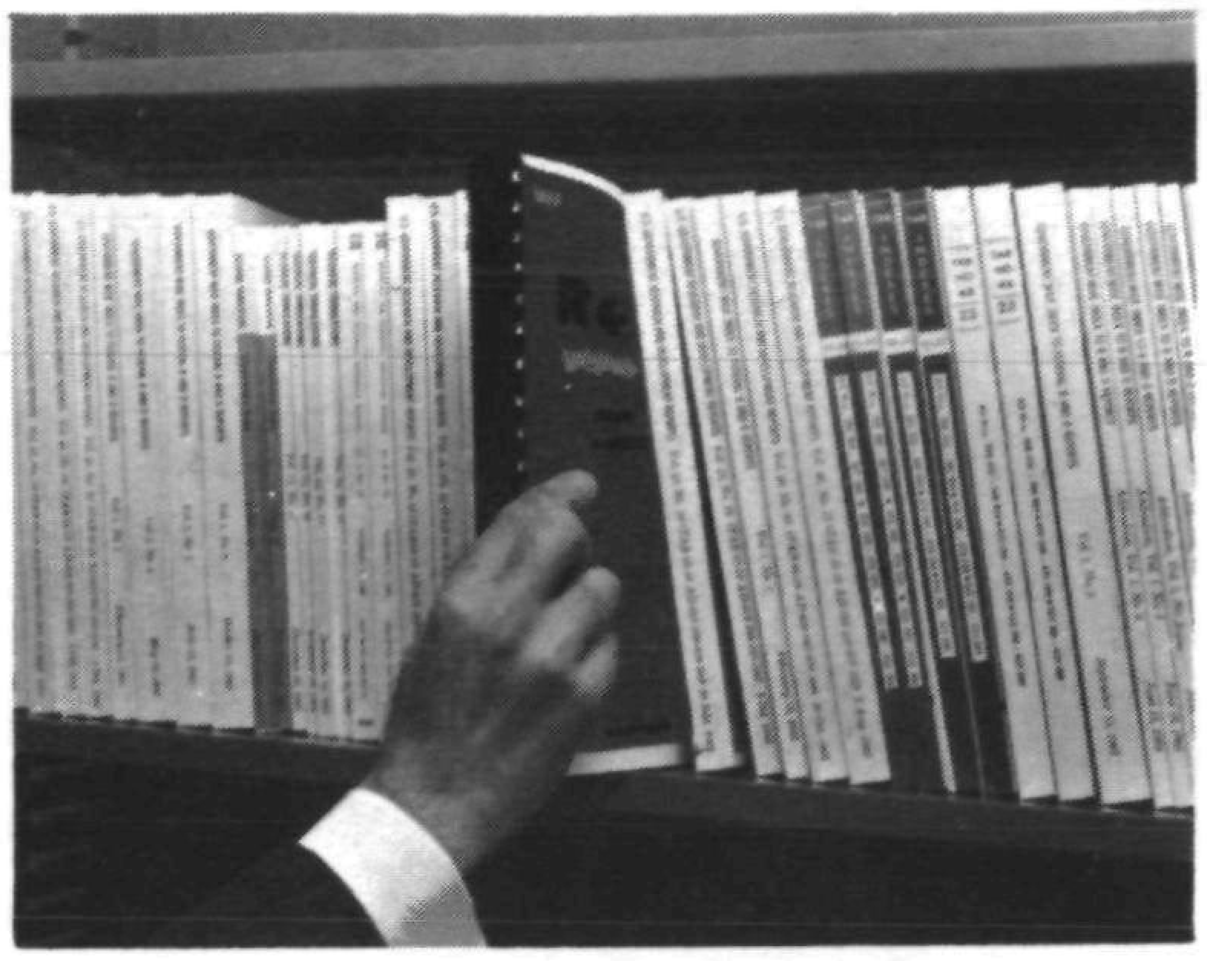

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U.S.S.R. LITERATURE ON AIR POLLUTION AND RELATED OCCUPATIONAL DISEASES

Volume 14

A SURVEY

by B. S. Levine, Ph. D.

Sanitary Protection of Moscow Atmospheric Air

M. S. Sokolovskii, Zh. L. Gabinova, B. V. Popov, and L. F. Kachor
(Moscow Sanitary-Epidemiological Station)

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Sanitarnaya Okhrana Atmosfernogo Vozdukha Moskvy
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Note

At the request of the District of Columbia Department of Public Health and with the cooperation of the Maryland State Department of Health Mr. Gene B. Welsh made an appraisal of "Air Pollution in the National Capital Area". Results of Mr. Welsh's efforts were published by the U. S. Department of Health, Education, and Welfare, Public Health Service, Division of Air Pollution, Technical Assistance Branch, Washington 25, D. C. as PHS. Pub. No. 955, July 1962. The publication is for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. - Price 35 cents.

A parallel reading of the present translation (Volume 14 of the USSR AIR POLLUTION LITERATURE SURVEY) and of Mr. Gene B. Welsh's "Appraisal of Air Pollution in the National Capital Area" should help American air pollution students to acquire a clear understanding of the difference in approach used in the USSR and in the USA evaluating the problems of air pollution in the respective capitals and in the various measures either suggested or actually adopted for the protection of the air purity of Moscow, USSR and of Washington, D. C. USA and its proximal area.

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CONTENTS

THE HYGIENIC SIGNIFICANCE OF THE ATMOSPHERIC AIR

The Soviet Union Communist Party devoted in its program considerable attention to problems dealing with planning and organizing public utilities in inhabited areas, such as installation of gas facilities, planting of parks, trees, groves, etc.; the necessity of conducting an effective struggle against pollution of the ambient medium, particularly atmospheric air is emphasized; protection of atmospheric air against pollution has been raised to the level of National Government responsibility. It is pointed out that air pollution by industrial discharges affected the nation's sanitary-hygienic living conditions and its economy. Many chemical substances discharged into the atmosphere are harmful to the population's health, and in addition cause considerable material damage and loss to the nation's economy. Hundreds of tons of substances, which could be recovered and utilized in production, fly daily into the air from smokestacks and ventilation installations. Protection of atmospheric air purity is no longer an exclusive concern of public health authorities; preservation of air purity is now of vital concern to the Soviet Government, to the Communist Party, to community organizations, etc. Atmospheric air of large cities and industrial centers, inhaled daily by their residents, is polluted by discharges from industrial plants and boiler houses, such as dust, soot, gases, vapors, aerosols, etc. The substances contained in such discharges are harmful to health, and exert a gradual unfavorable effect on the human organism. It has been estimated that a man inhaled an average of 1,200 li of air in 24 hours. Under such conditions even small pollutant concentrations in the air, penetrating into the human organism, can cause a variety of diseases.

Moscow is a large industrial center with different types of industries, In prerevolutionary Moscow plants and factories were located within the city limits, in residential quarters without sanitary breaks or protection zones, and production and processing plants had no installations for the purification of industrial discharges. The interests of the industrialists were of paramount importance and the interests of the populace were ignored. Old Moscow was planned according to the law of the existing economic system. No rational measures in an attempt to protect Moscow's atmospheric air could be planned or introduced; air pollution from surviving old plants' discharges still takes place in Moscow. Under present conditions Moscow's industrial establishments discharge a complex of solid and gaseous organic and inorganic chemical substances into the air causing considerable economic damage to the national economy through the destruction of decorative and shade trees, shrubs, parks, etc., through excessive fuel consumption due to incomplete combustion, through loss of rare metals and valuable chemical substances, through the destructive effect of sulfur dioxide on buildings, increased consumption of electric light power connected with loss in air transparency, etc. V. A. Uglov estimated in 1934 that the world's loss in coal alone, based on a 1% incomplete fuel combustion, amounted to 13,600,000 tons in 1935; Uglov also estimated that losses in sulfur dioxide discharged into the atmosphere from smoke stacks of the world's furnaces were equivalent to 38,200,000 tons of sulfuric acid, or almost three times the 13,000,000 tons of sulfuric acid produced in the world that year.

Losses due to air pollution in the USA in 1950-1951 amounted to 1,500,000,000 dollars; such losses have been estimated in England in 1947 at 100,000,000 pounds sterling, while the corresponding losses in France amounted to 240,000,000,000 francs ("Unesco Courier"). Damage caused to buildings in England has been estimated at 2,500,000,000 pounds sterling, the use of artificial illumination during one smoggy day in London was estimated to cost that city in excess of 20,000 pounds sterling. Kayzer and Munger (1952) estimated that copper extraction from foundry fumes resulted in savings of 27,000,000 dollars. Under certain meteorological conditions atmospheric pollutants amassed in the air causing incidence of acute sickness, which frequently increased the mortality rate among the weak, the sick, the elderly and among children. Alarmingly increased morbidity and mortality rates occurred among populations of Maas river valley in Belgium in 1930 and in the American city of Donora in 1948 as the result of harmful industrial gases accumulated in anticyclonic weather. A thick fog, observed in London in 1952, caused a sharp rise in morbidity and mortality among children and elderly persons. (V. A. Ryazanov, 1962) Cases of poisoning free from fatalities occurred in 1946 in Lancashire, England in the vicinity of a plant discharging fluorine compounds, and in 1949 in Scotland near an oil refinery. A haze and mist have been appearing recently with some regularity over Los Angeles on sunny days. The mist caused irritation of the eyes and of the upper respiratory passages, damaged vegetation, and automobile tire casings. Under the effect of ultraviolet radiation oxides of nitrogen contained in automotive exhausts discharged by more than three million Los Angeles automobiles decompose forming ozone. In the presence of saturated hydrocarbons - olefins - contained in automotive exhausts formed a toxic mist which during the frequently occurring periods of temperature inversion turned into the well known Los Angeles smogs.

Atmospheric air polluted by products of incomplete combustion, such as soot, different hydrocarbons, frequently contained 3,4-benzpyrene found to be a carcinogen. Some scientists are of the opinion that air polluted with flue gases and automotive exhaust fumes was largely responsible for the occurrence of lung cancer. Soot and sulfur dioxide are constant components of smoke formed during fuel combustion; sulfur dioxide is subsequently oxidized into sulfuric acid and sulfuric acid aerosol which act as irritants on the mucosa of the eyes and the respiratory organs. The harmful effect of highly dispersed coal ash, if suspended in the air above certain concentrations, has been described by foreign investigators abroad, and by M. S. Goldberg in the USSR, and is now well known to scientists and health authorities concerned with in the preservation of atmospheric air cleanliness.

ORGANIZATION OF THE MOSCOW SANITARY SERVICE ENGAGED IN PRESERVING THE CITY'S AIR CLEANLINESS

The sanitary-epidemiological station of Moscow City assigned the problem of protecting the cleanliness of the city's air basin to its Department of Atmospheric Air Hygiene which was organized in 1956. Prior to that, the protection of atmospheric air cleanliness had been the responsibility of two groups: 1) state sanitary inspectors, whose function was that of control, and 2) so-called, sanitary physicians, who supervised the means and methods used in protecting atmospheric air against pollution. In the early stages of Moscow air protection these two groups lacked direct contact, cooperation and systematic approach. Dust concentration in the air was first determined by the sedimentation method and later by the aspiration method. Attempts were made to reduce air ash content by compelling all types of boiler operated plants to use coal of the lowest ash and sulfur content, by installing ash and dust trapping equipment, etc. More effort was devoted by the authoritative construction organizations to the development and building of ventilation and air purifying installations in Moscow's most unhygienic industrial establishments from the viewpoint of air pollution.

Investigation of atmospheric air dust content by the aspiration method was conducted only on the territory of the Gor'kii Central Park of culture and Rest prior to 1945. In 1947 another testing point was established. In 1954 the Moscow sanitary-epidemiological station began to organize municipal and regional inspection points. By June, 1955 there were 5 municipal regional stationary inspection points in operation in Moscow. The Division of Atmospheric Air Hygiene, attached to the Section of General and Community Hygiene, had a staff which included physicians, an engineer, an assistant to the sanitary physician; it worked in close cooperation with the laboratory group which consisted of analytical chemists, a physical chemist and a laboratory helper; the scope of the work expanded considerably, operational control was centralized and coordinated, and consultation became an important phase of the total operation. Contact with regional sanitary epidemiological stations facilitated and hastened the process of solving basic problems related to the sanitization of Moscow's air basin. The Division recognized the significance of prophylactic sanitary control with direct leaning on rational preliminary planning, construction and equipping of industrial plants. Measures are considered for establishing sanitary protection zones around industrial establishments. This is being accomplished by relocating plants causing serious air pollution, moving residences out of sanitary protective zones, modernizing production technology, etc.

Staff members of the Atmospheric Air Hygiene Division participate in meetings of the sanitary and technical council of experts, at which questions dealing with basic factors related to sanitary protection zones are discussed, including selection of housing construction locations in vicinities of some industrial establishments, reconstruction and modernization of old plants, hygienic classifications of industries not covered by standard operating regulations, etc. Serious questions are also discussed at meetings of the council of experts in the F. F. Erisman Moscow Scientific Research Institute of Hygiene, and the Central Institute of Post Graduate Medicine, and of the USSR and the RSFSR Ministries of Public Health.

According to a decision of the Mossoviet (Moscow Soviet), complex problems related to the construction of purification devices must be discussed at the Technical Mossoviet Administration meetings in cooperation with air pollution experts. It has become a recent practice to study jointly plans submitted to the industrial section of the Municipal Sanitary-Epidemiological Station. The plans are first examined by experts of the Division with regard to sanitary protection of the atmospheric air: decisions are finally considered by the council of industrial experts with the participation of the Division's staff members. Construction of purification installations is supervised by sanitary physicians of the city and regional sanitary-epidemiological stations.

The Division of Atmospheric Air Hygiene issued routine standard instructions to be followed in conducting inspections of industrial plants with regard to a sound and rational construction from a sanitary hygienic viewpoint, means of production and processing operations, and with regard to ventilation and other air purifying installations. Instructions are periodically issued to regional sanitary epidemiological stations which deal with sanitary-hygienic problems arising in production departments pertinent to their authority. The City Sanitary-Epidemiological Station initiated an extensive project in 1958 dealing with the study of atmospheric air pollution by motor vehicle exhaust fumes on highways and by gasoline stations. A study was initiated in 1959 of widths of sanitary protective zones surrounding city enterprises which constituted principal sources of atmospheric city air pollution. The same year some regional sanitary-epidemiological stations initiated a study on the relationship between morbidity rates and degree of atmospheric air pollution by specific city enterprises.

In 1960 P. P. Dikun developed a fluorescent-spectral method for the detection of the carcinogen 3, 4-benzpyrene in atmospheric air pollutants and in settled dust. Following this fifteen city enterprises were selected for special study and determination of the amount of 3, 4-benzpyrene their discharges may have contained. Parallel with this, determinations were made of the amount of 3, 4-benzpyrene contained in the raw material and in the intermediate, finished, and processed products.

Dust was collected for such studies by the sedimentation and aspiration method. Results of the study determined the urgent need for and type of sanitary-hygienic installations which were to be recomended as prophylactic measures.

Serious attention has been given to park development, planting of trees, decorative shrubs, bushes and flower beds. In cooperation with other pertinent departments a study was made of industrial effluents' effect on the growth of vegetable life in the city parks, nearly forest groves and farms, and in the sanitary protection belt. Studies have been initiated for the exact determination of air pollution type and degree contributed by specific city enterprises.

Fig. 1 is a schematic presentation of the organizational plan according to which work for the protection of Moscow's atmospheric air purity is being conducted.

Fig. 1

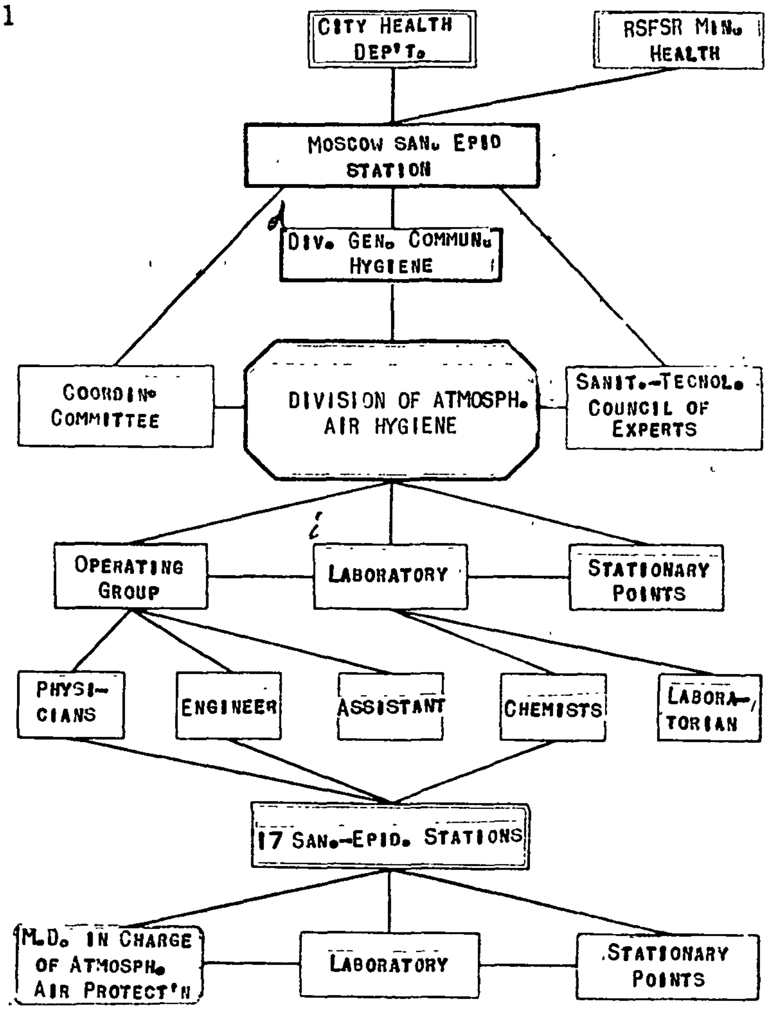


FIG. 1. ORGANIZATION OF MOSCOW SANITARY-HYGIENIC ATMOSPHERIC AIR PROTECTION

The Division of Atmospheric Air Hygiene functions in cooperation with the Mossoviet, the Mosgorsovnarkhoz (Moscow Economic Council), and the Institute of Basic Moscow City Planning, the Central Moscow Institute of Post Graduate Medicine, the F. F. Erisman Central Scientific Institute of Hygiene, the A. N. Sysin Institute of General and Community Hygiene of the USSR Academy of Medical Sciences, and many other functionally related institutes and organizations. Questions pertaining to general sources of atmospheric air pollution, city fuel supply, reduction in atmospheric pollution by automotive exhaust fumes, organization of sanitary protection zones, etc. are decided by the Mossoviet. Measures requiring substantial capital outlay by the city's industrial enterprises are decided on the basis of specific conditions by the Mosgorsovnarkhoz (Moscow City Economic Council). Based on information supplied by city regional sanitary-epidemiological stations, the Division prepares specific lists of purification installations which the City's economic Council anticipates through the year for distribution among Moscow's industrial enterprises.

The need to institute sanitary protection zones around Moscow's industrial enterprises is determined by sanitary authorities in cooperation with the Moscow Institute of General City Planning; simultaneously concrete sanitization measures are being developed and instituted according to specifications prescribed for each enterprise in compliance with standard city health regulations. With respect to park development, tree planting, etc. the Division cooperates with workshops of the General City Planning Institute, with the Planning Administration, the Public Welfare Department, and the Forest and Park Management Administration of the Moscow City Executive Committees, and several other pertinent institutes and organizations. In the field of atmospheric air protection against pollution by automotive exhausts, the Division cooperates with Institutes of the Automobile Industry, the Automobile and Internal Combustion Scientific Research Institute, the Auto-Transport Scientific Research Institute, the Fuel Supply Central Scientific Research Institute, and with the Main Moscow Motor Transport Administration of the Mosgorispolkom (Moscow City Executive Committee).

In recent years the Department has established contact with the Mosgorsdravotdel (Moscow City Public Health Department) for the cooperative study of population morbidity in relation to Moscow atmospheric air pollution. In this connection the City Sanitary-Epidemiological Station in cooperation with the Department of Municipal Hygiene of the Central Institute of Post Graduate Medicine convoked the First Moscow Topical Conference for the Sanitary Protection of Atmospheric Air in November of 1961. Approximately 450 practical workers, physicians, engineers and scientists, from hygienic and technological institutes actively participated in the conference. Among those who attended the Conference were representatives from Leningrad, Riga, Sverdlovsk, Tbilisi and Dnepropetrovak.

Twenty-five reports were presented at the conference which covered a wide scope of problems. Seven reports were presented by staff members of the Division of Atmospheric Air Hygiene, three by physicians of city-district sanitary-epidemiological stations in cooperation with staff members of the Division. Some technological problems were illuminatingly discussed in reports presented by members of NAMI (Automobile Internal Combustion Engine Scientific Research Institute), "Mosgazproeskt", and members of other pertinent research institutes and organizations.

Beginning with 1956 staff members of the Division have been engaged in work dealing with problems of pertinent applied sciences. Thus, in 1957 and 1959, members of Moscow Sanitary-Epidemiological Stations reported at an applied science conference on the state of the city's atmospheric air pollution as indicated by data secured at stationary inspection points; at the All-Union Conference on sanitary protection of atmospheric air held in Kiev in 1959, and an applied science conference convoked by the Moscow Sanitary-Epidemiological Station in 1960, reports were presented dealing with the effect of automotive exhausts on Moscow atmospheric air, and its pollution with CO and poisonous hydrocarbons. At the third Plenum session of the Committee on Carcinogens and Prophylactic Measures, a report was presented dealing with Moscow ambient air pollution with the carcinogen 3,4-benzpyrene. Studies are being conducted on the effect of industrial discharges on vegetation; methods and equipment are being developed for the automatic collection of atmospheric air samples and their analysis. Staff members of the Division are urged to attend meetings and conferences, to participate in discussions, exchange of experiences and opinions related to problems encountered in the course of their work.

A significant part of the Division's activity is devoted to advancing the professional qualifications of the scientific, semiprofessional and manual personnel of the Division. Since 1960 laboratories of the Division have been used as workshops to which sanitary physicians were assigned for a year's study of laboratory procedures directly or indirectly related to the sanitary protection of atmospheric air. The Division personnel and trainees, including sanitary physicians, hold frequent intramural conferences at which pertinent problems of immediate concern are discussed in detail. At present nearly all scientific and professional personnel have received such advanced qualification training. Two sanitary physicians have received advanced instruction at the F. F. Erisman Moscow Scientific Research Institute of Hygiene; one sanitary physician has completed correspondence courses on sanitary protection of the atmospheric air offered by the Department of Municipal Hygiene of the Central Institute of Post Graduate Medicine; another had spent thirty days at the Department of Radiation Hygiene of the above mentioned Institute; four sanitary physicians completed a special 122-hour course at the same Institute.

Two of the Division's sanitary physicians passed certain prescribed examinations and have been given the titles of Minimum Program Candidates.

Topical conferences are held and seminars are being conducted for sanitary physicians of regional city sanitary-epidemiological stations. All sanitary physicians of regional city sanitary-epidemiological stations engaged in the sanitary protection of atmospheric air cleanliness have taken the previously mentioned 122-hour program of advanced training at the Division of Municipal Hygiene of the Central Institute of Post Graduate Medicine. In addition, the Moscow City Sanitary-Epidemiological Station invites sanitary physicians, chemists and other scientific laboratory workers to engage in practical work conducted at the Station on a temporary training basis. The Division of Atmospheric Air Hygiene conducts lecture courses for auditors at the Central Institute for Post Graduate Medicine and at the F. F. Erisman Moscow Scientific Research Institute of Hygiene. Representatives of different cities and republics of the Soviet Union are periodically familiarized with the work of the Division.
A Committee attached to the office of the Chief Physician of the Sanitary-Epidemiological Station, has been assigned the task of coordinating all the work on sanitary protection of Moscow's ambient air. Included in such Committee are representatives of hygienic and technical institutes, individual Mossoviet administrations, the Mosgorsovnarkhoz, the Academy of City Administration, and other pertinent organizations.

SOURCES OF MOSCOW AMBIENT AIR POLLUTION AND MEASURES USED IN COMBATTING IT

A total of 1956 purification installations were listed on the books of Moscow Sanitary-Epidemiological Station in 1963. Table 1 shows the rate of annual growth in the number of purification devices.

Table 1

LIST OF PURIFICATION INSTALLATIONS

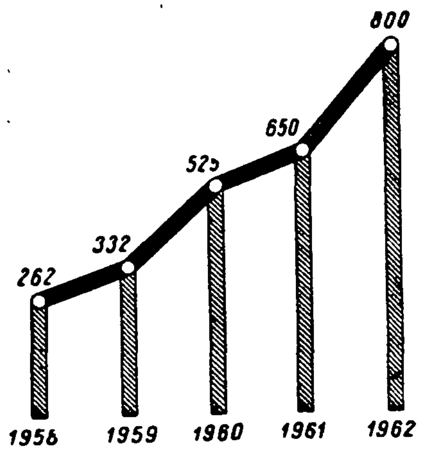
	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
NUMBER OF PURIFYING INSTALLATIONS	462	622	776	1153	1256	1367	1504	1586	1699	1956

NOTE: DATA SHOW INCREASED TOTALS

The Moscow City Sanitary-Epidemiological Station is conducting systematic work in developing improved methods for the manufacture of purification installations. Many purification installations are newly built and rebuilt at Moscow shops. Thus, 137 installations were built in 36

Moscow shops in 1960. The building of purification installations was accelerated and substantially increased during 1963-1965. This raises before Moscow sanitary organizations new imposing problems in the field of preventive sanitary supervision. The Department of Atmospheric Air Hygiene issues official decrees, list trade names of available purification equipment, makes known resolutions of the Mosseviet and enactments of the Moscow Chief Sanitary Physician on questions dealing with preventive sanitary supervision of protecting atmospheric air against pollution. Considerable attention is devoted by the Sanitary Service of Moscow to the installation of gas burning facilities in community and industrial boiler rooms and in industrial furnaces. The Division of Atmospheric Hygiene prepares annual lists indicating the order in which fuel combusting utilities should be converted to gas burning. Over 800 industrial plants had been converted to gas fuel; more than 100,000 home heating "ovens" and about 1200 boiler rooms of apartment houses and community heating facilities have been converted from hard fuel burning to that of gas; over 100 industrial buildings and 9000 residential buildings have been provided with gas burning heating facilities.

Fig. 2



BLOCKS SHOW NUMBER OF INDUSTRIAL ENTERPRISES ACCORDING TO INDICATED YEARS

Development of a special method made possible the detection of carcinogen 3,4-benzpyrene in the raw materials used by industrial plants which employed coal-tar pitch, tar mastic, and certain brands of soot. Results of studies conducted in the detection of 3,4-benzpyrene prompted the Chief Sanitary Physician to shut down a roof-paper making plant and to stop the production of tar cement at a Rubberoid plant. Wider use of the aspiration method in collecting air samples and the development of the fluorescent method for the detection of 3,4-benzpyrene should indicate with greater certainity the imperative need for shutting down industrial plants which pollute the air with carcinogens.

Considerable difficulty has been encountered in enforcing existing Mossoviet regulations prohibiting the open burning of industrial wastes. Not all industrial plants complied with this official regulation; this was particularly true of plants belonging to the woodworking industry. The introduction of a new unit designed for the combustion of wood waste with the shaft inside the combustion chamber, developed by engineer N. I. Kraitsberg, eliminated the discharge of smoke into the atmospheric air. The year 1955 marks the beginning of removal from Moscow of industrial combines and individual production plants which were responsible in greater part for Moscow's air pollution and which particularly disturbed the population with their discharges. Since 1955 29 plants and 73 shops have been removed from Moscow, which resulted in lowering the suspended dust, gas and sulfur dioxide concentrations in the atmospheric air. In many Moscow city districts air dust density has been reduced to 20-15% of what it was in 1950, and sulfur dioxide concentration in Moscow ambient air was reduced by 50% since 1956.

Intensity of air pollution by a variety of chemicals in the vicinity of Moscow plants which installed air purifying equipment inside their working premises has been reduced drastically. It can be stated with certainity that industrial production, manufacturing and processing plants constituted the basic sources of Moscow ambient air pollution. Industrial discharges emitted into the atmospheric air can be grouped into six categories: 1) combined tail gases thrown into the air in a centralized manner; 2) spent gases released by different technological processes involving equipment pressurizing, etc. and which are discharged in an unorganized manner; 3) air of localized exhaust ventilation, which contained high concentrations of suspended dust and gases; 4) air of general exchange ventilation containing pollutants in low concentrations; 5) unorganized discharges coming from leaky ventilation conduits, and 6) pollutants which get into the air during open loading and unloading of different types of loose or dust containing materials. Industrial plants can be characterized also on the basis of specific substances they discharged into the atmospheric air.

The Chemical Industry

Plants of the chemical industry polluted atmospheric air with oxides of nitrogen, sulfur dioxide, carbon bisulfide, ammonia, organic solvent vapors, acrolein, chlorine, complex volatile organic substances, and dusts. The chemical industry complex includes basic chemistry, - the production of acids, alkalies, salts, etc.; biproducts of coke chemistry; pharmaceutical chemistry; aniline-dye chemistry; lacquer and paint chemistry; natural and synthetic rubber chemistry, etc. Most chemical production processes possessed certain common harmful characteristics. A discussion of production processes which discharged into the atmospheric air the same of similar pollutants is presented in the following paragraphs. Plants which produced rubber or processed rubber articles use different kinds of soot and organic solvents in their production processes. By order of Moscow sanitary authorities, purification facilities had been installed at strategic discharge outlet points of such plants which served also as means for the recovery of solvents, and, in the case of filter bags, for the recovery of dustlike discharges, etc. Where the recovery of some chemical substances presented technical difficulties the problem was solved by altering the technological processes, by replacing the initial harmful substances by less harmful ones, by instituting closed cycle production, or by moving air polluting production cycles beyond the city limits.

Thus, at plant "Kauchuk", which manufactured a variety of rubber products, the basic source of atmospheric air pollution was the stage of preliminary processing in which synthetic and natural rubber and different brands of soot were used. This preparatory stage of production will soon be moved into a new building now under construction outside Moscow city limits.

Plants manufacturing artificial leather and leather substitutes use different solvents such as gasoline, acetates, etc., the vapors of which are being trapped by recovery installations, and gasoline soluble latex is replaced by water-soluble latexes, etc. Oil refineries which produced high-grade gasolines, paraffins, acetic acid, butane, lubricating oils, and crude oil cracking and pyrolysis plants, and other types of conversion plants operated in the open polluting the atmospheric air with sulfur compounds and saturated and unsaturated hydrocarbons, the recovery of which is difficult, costly and complicated. No practically reliable and economical means for the recovery of such products have yet been proposed, but the search for such procedures continues.

Raw materials used by plants of the dye industry include different hydrocarbons, sulfur and aniline compounds. Here different types of scrubbers are used for the recovery of dye dust, sulfur dioxide, hydrogen sulfide, oxides of nitrogen, ammonia, hydrocarbons. Paints and varnish producing plants discharged into the atmosphere entire complexes of organic solvents containing vapors of gasoline, xylol, white spirit, isopropyl alcohol, etc. The operation of such plants within the city limits of Moscow has been prohibited.

Plants producing drugs, pharmaceuticals and perfumes obtain alkaloids and other similar substances by extraction with dichlorethane and methanol, the vapors of which seriously pollute the surrounding atmospheric air. In addition plants which produced antibiotics discharged into the air surrounding the plants antibiotic dust, phenol, butanol, butyl acetate, sulfur dioxide, and an entire series of aromatic compounds and inorganic substances. The principal discharge components are recovered. Some of such pharmaceutical production plants have been moved outside the city limits. Such was the case with the Karpov chemical and pharmaceutical plant which used to pollute Moscow air with manganese. Another Moscow plant which produced potassium permanganate was completely shut down. The Semashko chemical and pharmaceutical plant has also been moved out of Moscow. A new plant is at present under construction outside of Moscow city limits which will house an endocrine preparations plant which is now operating in the heart of Moscow. Cleaning, dyeing and general chemical plants which could not be moved from Moscow have been ordered to equip their production and processing rooms with up-to-date pollution trapping and by- and waste products recovering equipment, such as scrubbers, filter bag dust catchers, etc. In accordance with the Moscow

City Sanitary-Epidemiological Station's proposal, the general city reconstruction plan provides for the construction of new buildings outside the built-up residential city area which will ultimately house all previously mentioned production and processing plants.

Sulfur dioxide is one of the most extensively encountered air pollutants of the chemical industry, as well as in many other industries. Gaseous discharges containing more than 4% of SO_2 can be utilized in the production of sulfuric acid. Gaseous discharges containing less than 4% sulfur dioxide can be purified with water, soda, ammonia, lime solutions, etc. The dilute sulfur dioxide solutions can be converted into weak sulfuric acid, sulfates and sulfites by the generally known combined methods. Hydrogen sulfide is recovered by different methods depending upon local conditions. The wet purification method employing soda, alkalies, arsenic, catasulfite, etc. are used most commonly. Wet scrubbers sprayed inside with milk of lime are used for the removal of chlorine. Depending upon the purification degree required the plant management can use the well known single or double stage wet scrubbers.

Hydrogen chloride is absorbed easily by water in packed scrubbers the purification efficiency of which can be as high as 95-96%. Industrial discharges containing mercury can be effectively purified with the aid of activated charcoal filters, pyroluside, potassium permanganate, etc. The recovery of oxides of nitrogen presents certain difficulties, and the purification method to be selected depended upon the ratio between the nitric oxides and the nitrogen peroxide. Organic solvents are generally recovered and recirculated into the technological cycle. A necessary condition for efficient recovery is a leakproof system of conduits and adequate suction installations at strategic production and processing points. It has been established that recovery installations operated efficiently at volatile pollutant concentrations of not less than 1000 mg/m^3. However, recovery of solvent vapors of lower concentrations must be resorted to for the adequate protection of atmospheric air purity.

Adsorption and absorption methods of solvent recovery are the most widely used at present. The adsorbent is usually activated charcoal or silica gel, and the absorbent is a suitable liquid. The purification degree depended upon the solvent, and generally amounted to 70-80%. Any residual should be burned by passing the mixture through a combustion unit. The solvent vapor recovery method has been employed successfully in Moscow for the recovery of toluol in printing shops, of ethyl acetate at furniture factories, in the production of artificial leather and leather articles, etc. Recovery of deep freeze gases proved to be of low efficiency, and, therefore, uneconomical.

Plants of the Nonferrous Metallurgical Industry

Many plants engaged in secondary processing of nonferrous metals are located within Moscow city limits, the discharges of which polluted the cities ambient air with lead, zinc, chlorides, pitch, coal dust, sulfur dioxide, carbon monoxide, etc. The copper electrolytic plant is the largest of all nonferrous Moscow plants.

Processing of raw metallic ore containing copper is done at high temperatures causing the formation of colloidal oxides of zinc and lead. To prevent the latter from heavily polluting the city's atmospheric air the plant is equipped with efficient purification devices, such as filter bag installations. Certain sanitization measures have been instituted in the plant and the production of crude copper has been curtailed, which resulted in a marked improvement in the sanitary condition of the surrounding air, but not enough to adequately improve the sanitary living conditions of nearby residents; therefore, some of the plant's production and processing departments were moved out of the city. The Moscow Electrode Plant used coal tar pitch, crude oil tar and pyrolyzed anthracite as raw materials in its technological and mechanical processes; the plant created and discharged into the air a large amount of dust, pitch volatilization products, a variety of sublimates and vapors, sulfur dioxide, carbon monoxide, etc. For the recovery of tars and particulate substances, highly effective electrostatic filters have been installed by order of the Sanitary Service. This has considerably reduced the pollution of atmospheric air in the vicinity of the plant. Electrostatic filters are at present being installed for trapping other air polluting plant discharges.

By order of the Moscow City Sanitary Service other plants engaged in secondary processing of nonferrous metals replaced their reverberatory furnaces by electric furnaces, basically revised production and processing procedures, reorganized one of the plants into a scientific research institute, moved individual production sections beyond the city limits, equipped some departments with installations for the recovery of nitrogen oxides, lead, etc.

The Construction Materials Industry

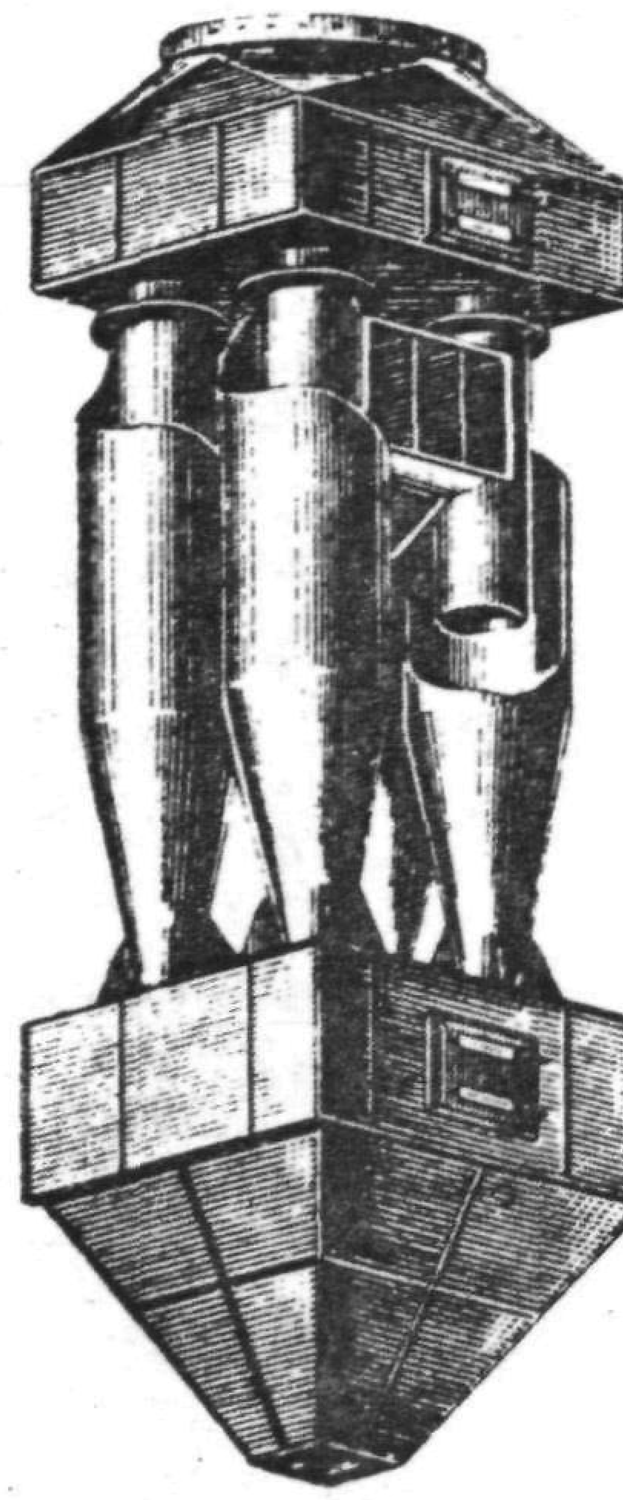
Moscow plants of the construction materials industry include asphalt-concrete plants, a group of plants engaged in the manufacture of different construction materials such as alabaster, bricks, glass, etc. and plants engaged in the production of roofing and insulation materials, etc. Asphalt-concrete and roofing materials plants are an intense source of Moscow air pollution with dust, soot, sulfur dioxide and many other harmful compounds, such as sand, gravel, calcareous powder, and petroleum asphalt. The basic raw materials used in the asphalt-concrete plants, such as rocks and limestone, are first finely crushed or ground, dried in drying drums at 120 - 140° C, and mixed with hot petroleum asphalt in special mixers. Laboratory investigations showed that preparation of the asphalt mass emitted discharges which heavily polluted the surrounding air. This was substantiated by complaints coming from local residents. Results of laboratory investigations showed that soot, dust and SO_2 concentrations in the air surrounding the asphalt-concrete plant over a wide belt exceeded their corresponding MAC by 100-200%. By request of the Moscow Soviet and by order of the Moscow City Sanitary Service most of the asphalt-concrete plants located within Moscow City limits were shut down and a new and modern plant was built in a special zone.

Stone and alabaster moulding, brick and glass making, reinforced concrete and some other plants use sand, cement, clay and other loose raw materials, which are finely pulverized before their final use; this results in atmospheric air pollution with dust. And, indeed the territory around the alabaster plant used to be heavily polluted. The Moscow City Sanitary-Epidemiological Station ordered the plant to install appropriate dust-catching equipment. Electrostatic precipitators were installed and put into operation, which reduced the air dust concentration in the vicinity of the plant to the MAC level.

Tar-paper and so-called rubberoid plants used some of the previously mentioned loose or running materials and coal-tar pitch the vapor of which contained 3,4-benzpyrene; their discharges heavily polluted the surrounding air. Based on results presented by the city sanitary laboratory, the Chief-Sanitary Physician of Moscow ordered that the tar paper and rubberoid plant be shut down. Elimination of air pollution by such plants required that all unorganized pollution leakage be stopped, and recovery of valuable discharges be instituted by installing suitable cyclones, electrostatic precipitators, or other suitable air purifying equipment. Boiler rooms of gypsum producing plants should be equipped with a four-stage air purification system consisting of battery cyclones, bag filters and electrostatic precipitators of up to 99% efficiency.

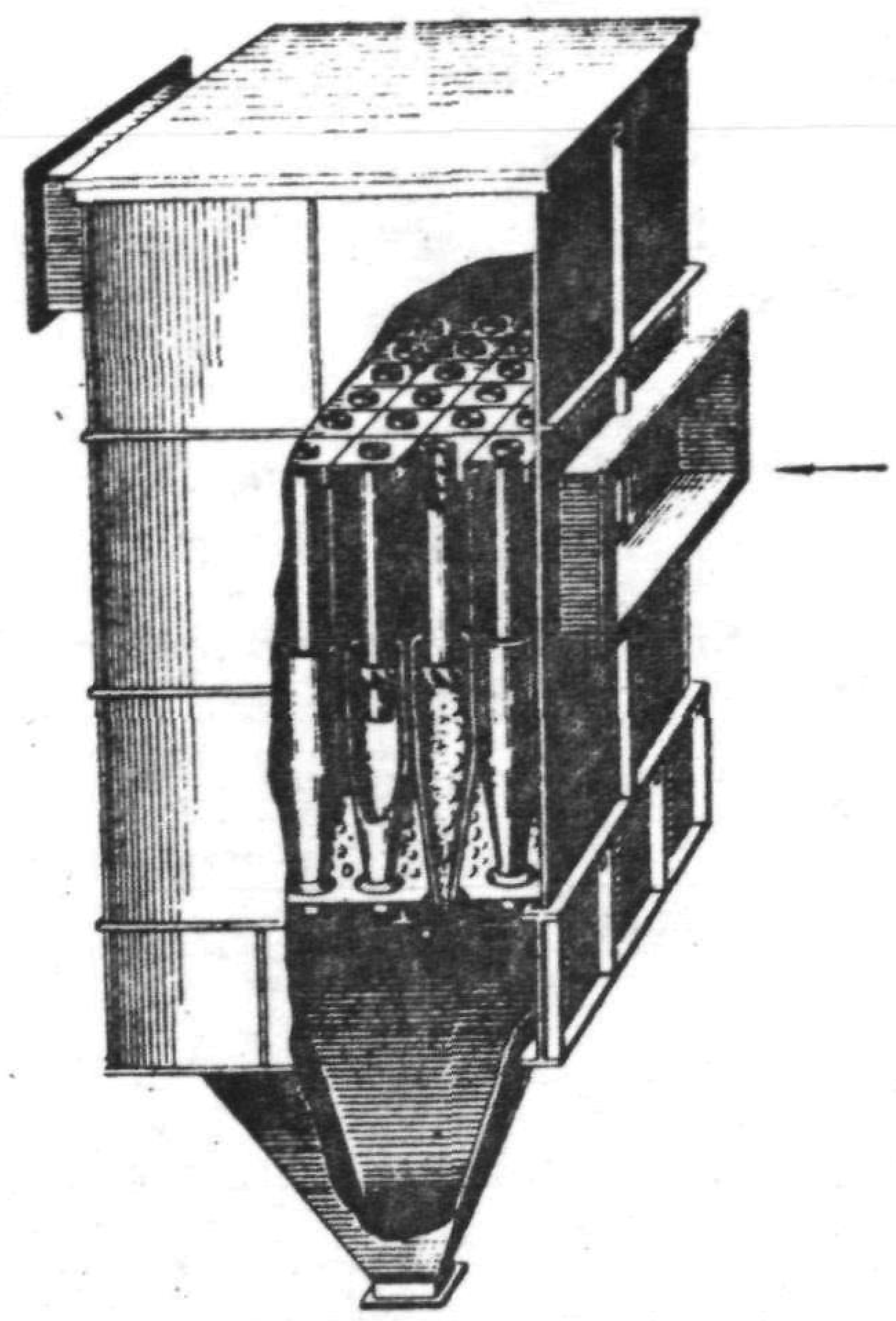
Figures 3 and 4 show the NIIOGAZ cyclone and a battery cyclone (multicyclone) used in Moscow industrial plant engaged in the production of a variety of construction materials.

Fig. 3



CYCLONE
NIIOGAS

Fig. 4



BATTERY CYCLONE
(MULTICYCLONE)

The Metalworking and Machine Building Industry of Moscow

Most of the production and processing plants of Moscow belong to the metalworking and machine building industry. All such plants discharged into the atmospheric air similar monotypical pollution components which are of a benign character. In addition, Moscow houses shops engaged in casting, galvanizing, etching, painting and forging which polluted the air with dust, metal oxides, carbon monoxide, sulfur dioxide, vapors of acid and alkalies, compounds of manganese, zinc and chromium, nitro dyes, and other compounds.

Air pollution in the casting shops comes from the cupola-furnace exhaust gases and ventilation discharges. Cupola-furnace exhaust gases contain up to 10 - 15 g of dust per m^3 of gas, up to 15% carbon monoxide and up to 1% sulfur dioxide, all of which are thrown into the surrounding air without previous purification. Foundries and casting shops polluted the atmospheric air with ventilation exhausts containing quartz dust generated during ground molds preparation, cast cleaning, etc. Dust-laden air coming from casting shops through ventilation systems or through aeration skylights entered the atmosphere and polluted it. This is particularly true of ventilation air coming from earth-preparation cast cleaning sections.

Ventilation air coming from sand-blasting chambers contained as high as 175 g/m^3 of sand, 50% of which may be in the form of silicon dioxide. In the forge shops of machine building and metalworking plants air pollution comes basically from hearths used in preheating of the material to be forged; in this case the pollution components are smoke containing carbon monoxide, soot, and a small amount of sulfur dioxide. Furnaces used by plants forging objects of large dimensions and which burned mazut are serious sources of air pollution. Paint shops, especially the ones which employed the spray system come next. Paint shops can discharge into the air tons of solvents, including acetone, benzene, toluol, acetates, etc. Modern machine building plants do a considerable amount of electric welding. High grade electrode coating and welding fluxes contained such substances as manganese and fluorides. In the course of electric welding manganese aerosols and hydrogen fluoride are generated which entered the air of the shop and therefrom permeated into the atmospheric air through the ventilation conduits and also as a result of unorganized pollution through the aeration skylights.

Industrial shops which used the process of pyrolysis, etching and pickling also polluted Moscow ambient air with sulfuric acid aerosol, soot hydrocarbons, etc. Furnaces used in the process of pyrolysis and which burned liquid fuel polluted the atmospheric air with carbon monoxide, soot, and sulfur dioxide. Some machine building plants have nonferrous casting departments which remelted lead or other nonferrous metals. Galvanizing shops polluted the atmospheric air with hydrogen cyanide, dust, sulfuric acid aerosol, etc. No technical solution has been found until recently for the abatement of atmospheric air pollution by toxic discharges coming from cupola furnaces.

Preliminary plans have been submitted recently for the construction of effective cupola furnace air purifiers. A few cupola furnaces have been provided with such air purifiers on an experimental basis. The expected efficiency of the first purification stage lies between 70 and 80%. Smoke gases underwent final purification in a foam washer with a calculated efficiency of 95% or higher. Such cupola furnaces are being installed in a number of Moscow plants according to plans of the "Santekhnika" Scientific Research Institute. Ventilation air of casting shops has been undergoing purification in conventional cyclone scrubbers, fabric bag filter installations, and the like, which operated at 90 and 92% efficiency.

Conversion of forge and pyrolysis furnaces to burning gas fuel decreased the volume of their discharges into Moscow's ambient air. Paint shops of machine building plants using the spray method are being equipped with hydro filter chambers which trapped the paint aerosol and not the solvent vapors; therefore, the recovery of solvents in plants using large amounts of solvents must be done by appropriate ·upplementary installations. Polluted air discharged by galvanization plants can be purified best by electrostatic filters, or glass fiber bag filters, or by passing it through alkaline solutions.

Discharges containing non-ferrous vapors, sublimates, aerosols, or fine particulates must be purified in strict accordance with sanitary-hygienic specification, since they contained toxic substances such as oxides of lead and other nonferrous metals. This can be accomplished best by using one stage scrubbers, or two-stage cyclones and cloth bag filter installations.

The Woodworking Industry

City atmospheric air may be polluted by discharges coming from furniture factories, woodworking shops, pencil factories, etc. Ventilation air discharged by plants of the wood processing industry contain dust, carbon monoxide, organic solvents, phenols, and the like. In addition a considerable quantity of wood waste in the form of sawdust, shavings, and lath fragments accumulated daily at all plants which use cyclones of different types for the recovery of sawdust. Part of the wood waste is used directly by the plants as secondary material. Part is shipped to other plants, and part is burned. However, the boiler room combustion units have not been universally adapted to wood waste burning, and there arise cases of intense air smoke pollution; therefore, burning of smoke-creating wastes is forbidden by order of the Moscow Soviet. Twelve Moscow woodworking plants installed the combustion unit designed by engineer N. I. Kraitsberg, which can attain complete smokeless combustion of substandard grade wood wastes containing 60% or more of moisture. Furthermore, the combustion unit can be easily adapted to all known steam boiler designs. The basic element of the combustion unit is a rectangular cross section shaft lined with chamotte brick. The side walls have many cells. The shaft is seated inside the combustion unit, perpendicular to its front wall. The space between the shaft side walls and the side walls of the combustion unit form two channels, each of which is partitioned horizontally; the lower section forms the draft channel, and the upper the fire channel, and the two are connected by the combustion chamber. In the waste wood burning process the draft passes through the combustion unit twice bringing about complete combustion of the waste wood, eliminating smoke formation.

Motor Vehicle Transport

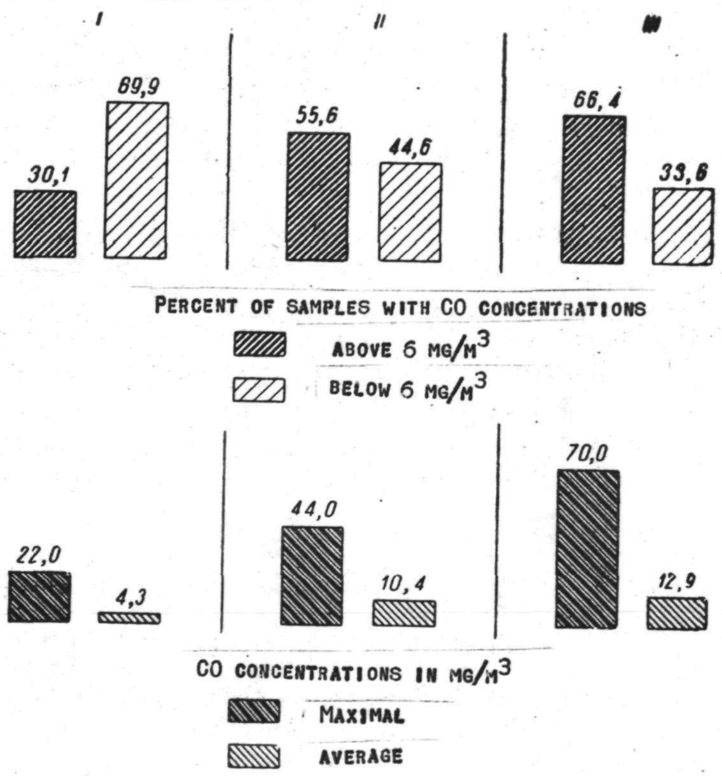
The number of motor vehicles has been increasing in Moscow with each year. Construction of new suburban apartment blocks at considerable distances from the old city boundaries necessitated expansion of bus and taxicab transportation and increase in the number of public motor vehicles in Moscow to more than 200,000, which created the need for protecting Moscow street air against pollution by automotive exhausts containing a complex of toxic substances, such as carbon monoxide, nitrogen oxides, hydrocarbons, formaldehyde, etc. Concentrations of these substances in automobile exhaust fumes frequently exceed the permissible levels. Carbon dioxide is probably the most significant toxic compound of the automotive exhaust complex. The maximal single permissible concentration of carbon monoxide in atmospheric air is 6 mg. m^3. Investigations conducted in many cities of the world showed that this value has been most generally exceeded. According to data reported by American authors Saper, Kaming, Asbell and Bloomfield in 1937 the street air of large USA cities contained between 90 and 138 mg/m^3 of carbon monoxide. According to Z. V. Vol'fson and A. S. Lykova the street air of the largest USSR cities contained 17 - 18 mg/m^3 of carbon monoxide in 1956. Results of studies conducted by the present authors on the arterial highways of Moscow indicated carbon monoxide concentrations ranging from 4.3 to 12.9 mg/m^3, varying with volume of traffic intensity and the width of the thorofare. However, D. P. Partaev found in 1962 that CO concentrations in Moscow street air was considerably in excess of the official MAC.

Carbon monoxide and other toxic substances are released into the atmosphere as a result of incomplete fuel combustion. The amount of carbon monoxide in the automotive exhaust depends on a complex of factors: the technical condition of the engine, its proper tuning up, its design, fuel quality, general operating conditions, organization of highway traffic, condition of the thorofare, meteorological factors, etc. Exhaust gases of an automotive engine in proper mechanical condition and fuel ignition and combustion adjustment contained from 1 to 3% carbon monoxide; a poorly adjusted engine under heavy operating conditions will emit exhaust fumes containing up to 13% of carbon monoxide. Exhaust gases varied to a considerable degree with fuel quality. The use of gasoline brand A-70 yielded half as much carbon monoxide as did gasoline A-56. The 200,000 Moscow motor vehicles consumed daily about 2500 t of gasoline and 500 t of diesel oil. It has been estimated that combustion of 1 t of gasoline liberated approximately 600 - 800 t of carbon monoxide. The danger is here aggravated by the fact that carbon monoxide did not dissipate, but persisted in the air within the level of respiration.

The Moscow Sanitary Service conducted a systematic study of the degree of atmospheric air pollution by motor vehicle exhaust fumes, and of measures for the abatement of the harm caused by these fumes to the health of the city's residents. Carbon monoxide content in atmospheric air is being studied in Moscow and other cities at fixed points in the residential and park zones, at four points in the industrial city districts with low motor-vehicle traffic, and at 4 selected points on the capital's automobile highways. Air samples are being collected also at streets having fluctuating rates of traffic and are tested for carbon monoxide, hydrocarbons, nitrogen oxides and formaldehyde. Over 2000 such air samples have been collected and analyzed in the course of the past three years.

The Moscow Sanitary-Epidemiological Station collected air samples in streets with fluctuating traffic: low motor-vehicle traffic - up to 300 per hour; traffic of medium intensity - 900 - 1000 motor vehicles per hour; high-intensity traffic - 2000 motor vehicles per hour and over (Figure 5). As motor vehicle traffic intensity increased, atmospheric air pollution with carbon monoxide rose with respect to number of samples containing CO in excess of 6 mg/m^3, and with respect to the average maximum. As was previously mentioned, atmospheric air pollution with carbon monoxide varied with the volume of passing traffic, and with the width of the street, or the street air ventilation.

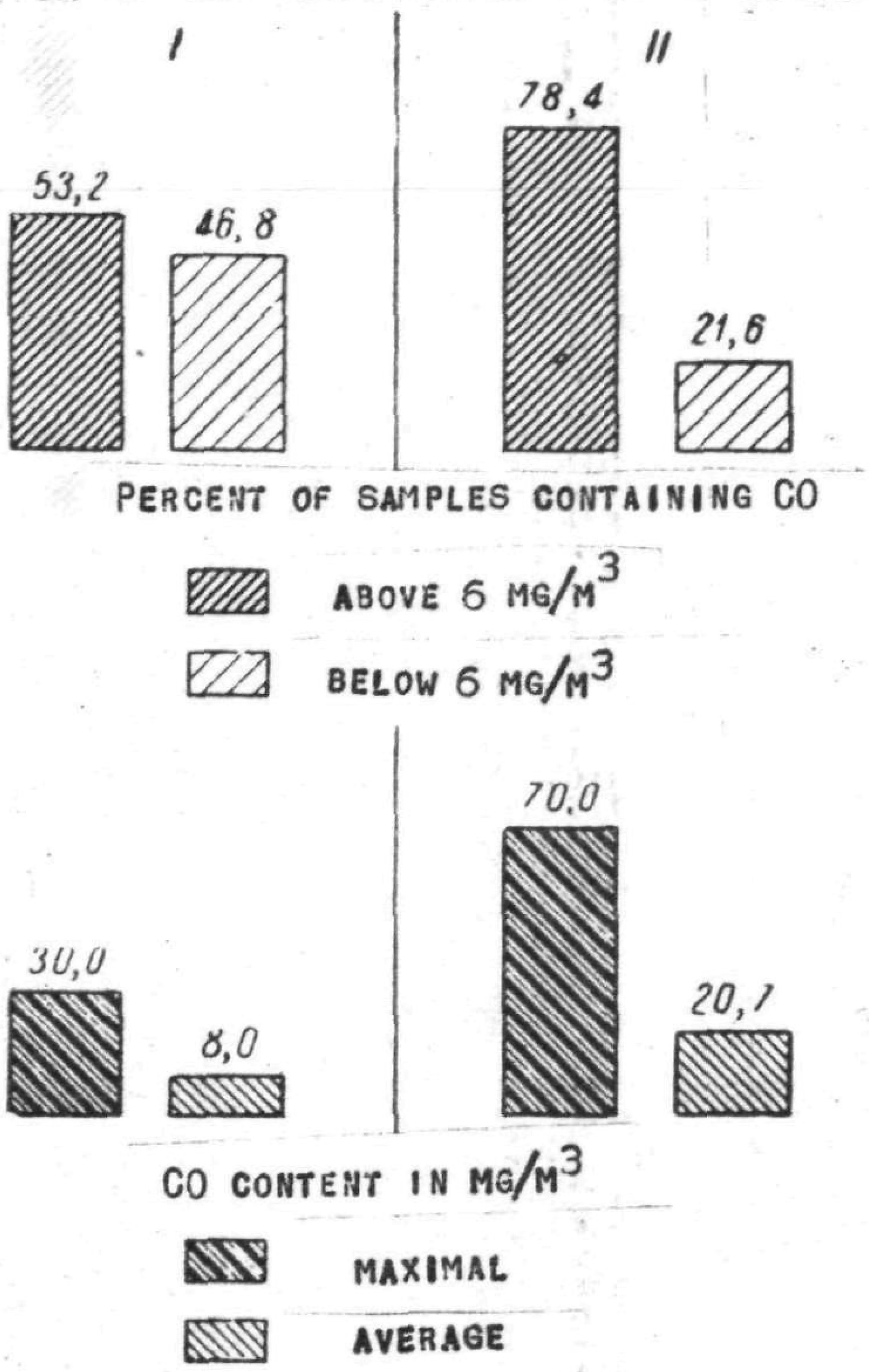
Fig. 7



ATMOSPHERIC AIR POLLUTION WITH CO IN RELATION TO RATE OF AUTOMOBILE TRAFFIC
I - UP TO 300 VEHICLES PER HR.; II - UP TO 1000; III - UP TO 2000 OR MORE

The rate of automotive traffic passing through Sadovo-Sukharevskaya Street, Dzerzhinskii Square, Enthusiasts' Highway and Sadovo-Triumfal'-naya Street is about the same. The first two highways are 35-40 m wide and have good ventilation; whereas Sadovo-Triumfal'naya Street is only 16 m wide (Figure 6).

Fig. 6



CO CONCENTRATION IN RELATION TO THOROUGHFARE WIDTH AT SAME MOTOR TRAFFIC RATE

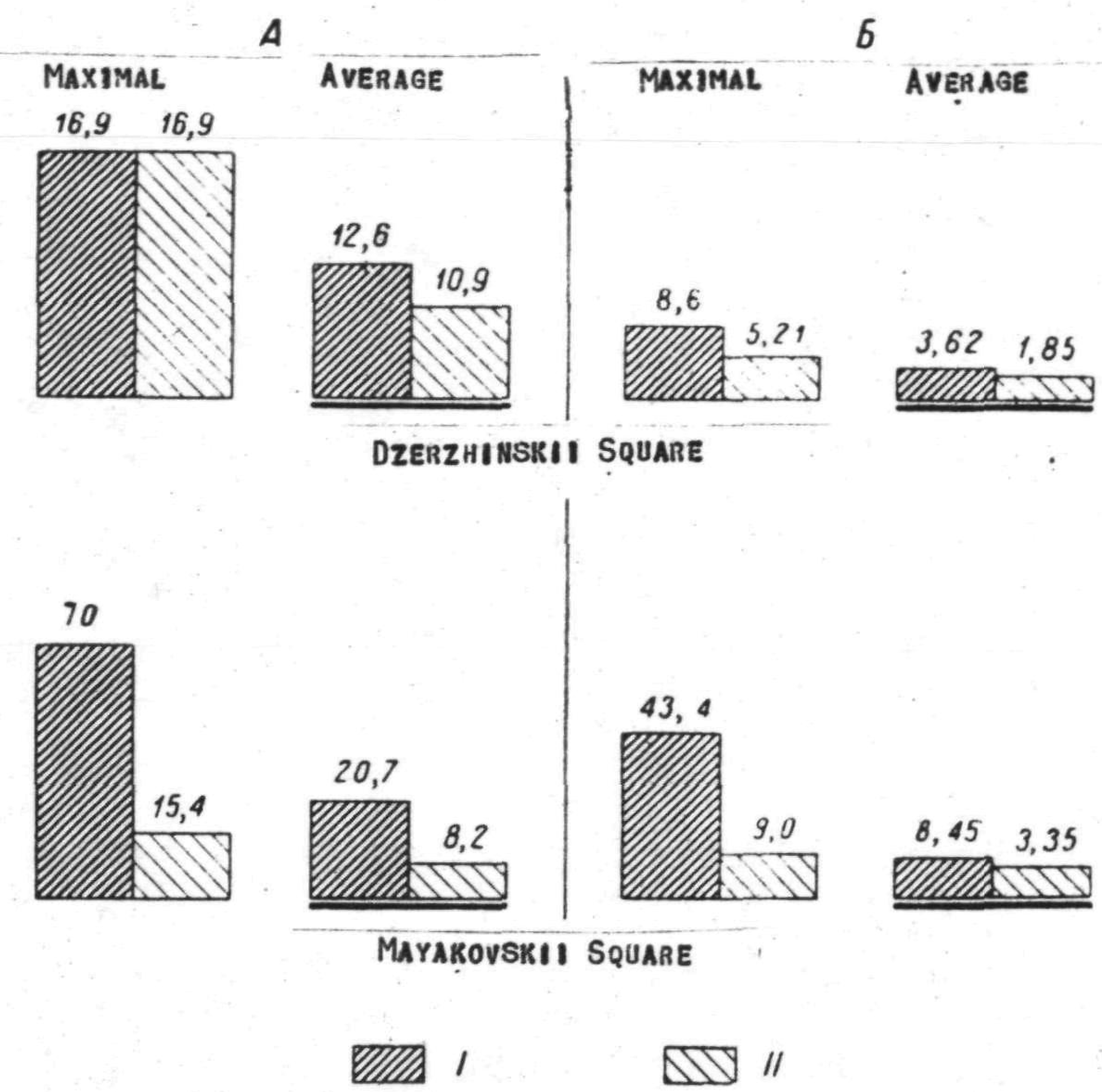
I - THOROUGHFARE WIDTH 35 - 40 M; II - 10 M.

Air studies conducted in streets of equal motor traffic intensity, but of different widths, showed that the air of narrow streets contained on the average twice as much carbon monoxide as did the air of the wider streets, and that number of air samples containing CO in excess of MAC was greater by 50% than in air samples collected in the wider streets. Construction of underground pedestrian street crossings and of tunnels for uninterrupted high-speed automotive traffic has been increasing in Moscow since 1959. The present authors tested the beneficial effect of street crossings and tunnels on the sanitary condition of the atmospheric air. It has been established that highest concentrations of toxic substances are exhausted by motor vehicles during acceleration, deceleration, and idling, especially when stopping at a traffic light; therefore, air samples have been collected for the determination of carbon monoxide and hydrocarbon concentrations at spots where cars stopped at a red light, before the construction of underground street crossings; similarly air samples have been collected at the same spots after the stop lights had been removed. Analysis of the air samples showed significant reduction in the carbon monoxide concentrations, and a perceptible reduction in the concentration of hydrocarbons in air samples collected after the removal of the red stop lights as illustrated by blocks in Fig. 7.

A considerable sanitizing effect was attained after the construction of an underground tunnel across Mayakovskii Square. Carbon monoxide and hydrocarbon concentrations were considerably reduced (see Figure 7).

Intensity of the atmospheric air pollution with hydrocarbons also increased with increase in the automotive traffic rate. Maximal air pollution concentrations in streets of low auto traffic rate were 3,4 mg/m^3, and in streets of high auto traffic rate (1000 vehicles per hour) maximal air pollution was 4.25 mg/m^3. Intensity of air pollution with oxides of nitrogen also varied with traffic intensity from concentrations below MAC to concentrations exceeding it. Formaldehyde concentrations in Moscow atmospheric air varied between 0.008 - 0.012 mg/m^3.

Fig. 7



FALL IN (A) CO AIR POLLUTION AND (B) HYDROCARBON AIR POLLUTION AFTER INSTITUTING OVERHEAD AND UNDERGROUND PEDESTRIAN PASSAGES. AIR POLLUTANT CONCENTRATION (I) BEFORE AND (II) AFTER THE INTRODUCTION OF SPECIAL PEDESTRIAL PASSAGES

Filling stations also polluted Moscow street air. Most Moscow gasoline stations supplied more than 15 t of gasoline every 24 hours. At 30 m the filling stations gasoline vapors in the air averaged 7.1 mg/m^3, and the odor of gasoline was unmistakably perceived. At 50 m the gasoline vapor concentrations dropped to 5 mg/m^3 which is below the MAC.

Introduction of new types of motor vehicles operating on gaseous fuel confronts sanitary supervisors with a number of new problems related to the evaluation of their effect on the sanitary condition of atmospheric air. According to laboratory data of the Research Automobile and Automobile Engine Institute, carbon monoxide was practically absent in exhaust fumes of the ZIL-164 vehicle, which operates on liquefied gas.

Air samples were collected directly at the discharge flume 10 cm and 2 m from the end of the exhaust pipe of a ZIL-156 automobile operating on compressed gas and on gasoline. Carbon monoxide and hydrocarbon concentrations were determined in samples collected when the vehicle was idling. The results of the tests are shown in Table 2.

Table 2

CARBON MONOXIDE AND HYDROCARBON CONTENT IN EXHAUSTS OF THE ZIL-150 AUTO-ENGINE AT IDLING

SAMPLES COLLECTED AT CM FROM THE EXHAUST PIPE END	ENGINE COMBUSTED GASOLINE		COMPRESSED GAS	
	COCN. IN MG/M^3			
	CO	HYDROCARBONS	CO	HYDROCARBONS
10	279,3	1014,2	71,5	7,3
	478,8	991,1	53,0	7,46
	118,7	151,4	11,0	3,83
200	106,4	79,8	17,0	4,75

The Moscow Sanitary-Epidemiological Station in cooperation with the Leningrad Central Scientific Research Institute of Fuel Equipment conducted tests in 1962 on a PAZ-651 bus with a spark ignition system and a jet ignition system for the purpose of determining the sanitary-hygienic effectiveness of the new ignition system. In the new jet ignition system special chambers take the place of spark plugs; a mixture of light gasoline fractions and basic cylinder fuel is fed into these chambers. The mixture is ignited by a spark plug and a jet is projected through the opening of a nozzle into the principal combustion chamber of the cylinder, in which an air-fuel mixture is ignited. Intensity of the mixture ignition in the cylinder brings about a more complete fuel combustion than in the case of the simple spark ignition system.

An engine with a standard spark ignition system and one with a jet ignition system were tested under identical conditions.

Samples of exhaust fumes were taken with the engines idling at 500, 1600 and 2200 rpm, and with the vehicles traveling at 20, 30, 50, and 70, and 90 km/hour. A-56 type of gasoline was used in all tests.

Results are shown in Table 3.

Data in Table 3 show that when the engine was operating with the jet type ignition, lower concentrations of carbon monoxide were detected than when the standard spark ignition system was used. However, equally high CO concentrations were obtained when the bus was travelling at a speed of 90 km/hour; this constituted an overload condition for the engine GAZ-51 installed in bus PAZ-651, since its maximum rated speed was only 70 km/hour. The jet ignition system proved more effective than the standard spark system during idling.

Gas-filling or charging stations can also constitute sources of atmospheric air pollution. Natural illuminating gas supplied by such stations consists of the following: carbon dioxide - from 0.5 to 2.2%; heavy hydrocarbons - up to 0.6%; oxygen - from 0.1 to 0.4%; carbon monoxide - from 1.1 to 4.9%; methane - from 81.3 to 92.7%; hydrogen - from 9.8 to 16.7%, and nitrogen up to 5.8%, and in some cases hydrogen sulfide up to 0.017% g/m^3. This gas has a high fuel value - from 7241 to 8267 Cal. One charge of this gas is sufficient for a truck run of 250 - 290 km. Moscow has at present several compressed fuel gas public stations.

Table 3

PERCENT OF CO IN EXHAUST GASES GENERATED BY AUTOBUS PAZ-651

NATURE OF WORK	CO IN %	
	IGNITION	
ROAD TESTS AT TRAVEL SPEED IN KM/HR	SPARK	JET
20	8,8 8,6 8,9	0,8 0,6 0,4
30	5,1 6,2 5,6	0,4 0,3 0,2
50	1,0 1,3 0,9	0,8 0,5 0,5
70	2,6 0,6 1,2	0,4 0,3 0,4
90	5,3 4,3 3,8	6,4 6,1 5,9
IDLING AT RPM 500	5,9 7,8 7,9	0,7 0,8 0,7
1 600	5,1 5,1 5,0	0,6 0,6 0,6
2 200	1,6 4,0 3,7	0,7 0,9 0,5

The natural gas is supplied by pipelines and is fed by compressors into central storage tanks,and from there into a net of gas-distributing pump stations. The atmospheric air at such points is polluted by fumes of the natural gas, by exhaust fumes of the serviced automotive vehicles. It has been established by laboratory tests that a 50-meter break zone may be sufficient as sanitary safeguard for service stations supplying compressed natural gas. As a measure of noise abatement and prevention of atmospheric air pollution with motor-vehicle exhaust fumes, the Moscow Sanitary-Epidemiological Station issued a regulation in 1954 prohibiting the use of diesel-engine buses within Moscow city limits.

When the use of ethyl gasoline in Moscow was under discussion in 1956 the city sanitary-epidemiological station investigated the lead content of atmospheric air on highways at city approaches where automobiles operating on an ethyl lead gasoline were passing by. Results of the study showed that in the course of gasoline combustion tetraethyl lead decomposed into other less toxic compounds, such as lead oxide, lead bromide, lead chloride, lead phosphate, etc., and that 80-85% of the lead contained in ethyl gasoline was eliminated. Based on the results of the investigation city sanitary authorities issued a regulation forbiding the use of tetraethyl lead gasoline within Moscow City limits.

In 1960 and 1962 The Executive Committee of the Moscow Soviet issued decrees dealing with measures for the reduction of atmospheric air pollution by exhaust fumes of automotive engines. A temporary technical standard was established at 2% maximum permissible carbon monoxide content in exhaust fumes of trucks and buses. Existing requirements for the maintenance and repair of automotive vehicles were supplemented by stricter requirements aimed at improving the engines' mechanical performance and at reducing the carbon monoxide concentration in the exhaust fumes. The City's Traffic Control Department and the Government Motor Vehicle Inspection should institute a strict check on the technical condition of engines, their fuel and ignition systems, etc.; the fuel combustion efficiency should be checked with special reference to CO concentration in the automotive exhaust fumes. Motor vehicle operators were requested to acquire Ors-Fisher carbon monoxide determination instruments. Managers of organizations which had motor-vehicle transport fleets were under official orders to observe a strict routine for the prevention of faulty engine functioning through proper maintenance of the carburetion and ignition systems. Following the issuance of the motor vehicle maintenance regulations inspectors of the Moscow Traffic Control Departments and of the Government Motor Vehicle Inspection condemned over 4500 vehicles for reasons of faulty operation and intensive atmospheric air pollution.

Fuel Combustion

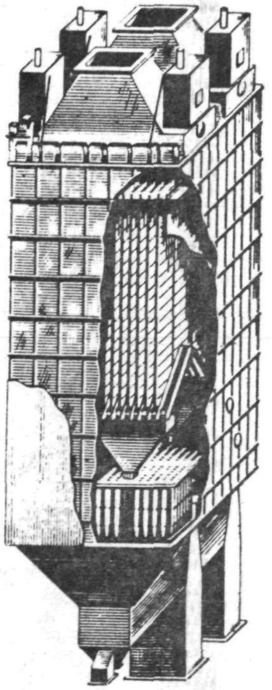
Moscow's general growth was paralleled by fuel consumption for industrial, community, and general utility purposes. Thus, twice as much Donets coal was burned in Moscow in 1960 as in 1946; the consumption of low-calorific and high-ash Lower M scow coal sharply fell to a low level, while consumption of gas increased by 24.0%.

Degree to which a fuel polluted the atmospheric air depended on its ash and sulfur content. The ash content of a fuel varied with the amount of mineral substances present in the coal, and by the mechanical admixtures originally present in it. The mineral substances present in coal cannot be removed and constitute only a small part of the entire ash; the mechanical admixtures constitute the principal incombustible mass of coal ash and can be partially removed by preliminary sorting and washing of coal or by the, so-called, enrichment process. The ash content of different hard fuel types varies greatly. Good Donets anthracite of the AP (plate anthracite) brand has an ash content of 4.5%; lean Donets coal contains 15% of ash; Podmoskov'ye (Lower Moscow) coal contains up to 30%, while peat and shale contain as much as 50% ash. In contrast to this, mazut and gas yield practically no ash. Sulfur content in fuel also varies: its concentration in Donets coals is 1 - 2.5%; in Podmoskov'ye (Lower Moscow) coal it is 2.5 - 4%; in shales its range is 3 - 4%; in mazuts it varies between 0.5 and 4.5%. Sulfur is practically absent in gas.

Fuel burning is accompanied by the discharge of ash and sulfur dioxide into the atmospheric air in proportion to their content in the fuel. Therefore, in order to diminish discharges, preference should be given to low-ash and low-sulfur high-caloric fuel. The best fuel from this viewpoint is gas, since it contains no ash and no sulfur. Sulfur is contained in coal in the organic, sulfate, and sulfite forms. Sulfate sulfur becomes a part of the ash and plays no part in the formation of sulfur dioxide; sulfur of the other two forms burns up completely in the combustion chamber and is converted into sulfur dioxide and, to a slight extent, sulfur trioxide. Organic sulfur is present in coal in an insignificant constant proportion; sulfite sulfur, such as pyrite and marcasite admixtures, are invariably present in varying concentrations. Sulfur and ash concentrations in coal can be considerably reduced by enrichment processes lowering the intensity of air pollution with SO_2 ash.

Coal concentration, or coal enrichment, is an important factor in reducing carbon dioxide discharges, since recovery of the latter by special installations is expensive. Ash intensity contained in fuel combustion discharges thrown into the air depended on the fuel ash content and on the design of the combustion chamber. Layer fuel combustion liberated only 20-30% of the total ash, the bulk of it is trapped by the slag; burning of powdered coal liberates 80-90% of the ash. Coal-dust combustion chambers differ from the fire-grate type in that the coal is burned not over grates, but in a suspended state in the form of free dust, blown into combustion chambers through special nozzles which resulted in more complete combustion and less soot, so that the smoke did not have the black color which characterized the smoke coming from fire-grate combustion chambers. Low grade coal, rich in mineral admixtures and having a low caloric value, is easily and completely consumed in coal-dust combustion chambers due to the large total area of the pulverized coal particles. Conversion to the coal-dust combustion method makes possible the use of extensively occurring local low-grade coal in power plants. Coal-dust combustion chambers liberate a high percentage of light coal ash which is a great disadvantage from the viewpoint of air sanitation. Recently coal-dust combustion chambers have been designed and built on the principle of liquid slag removal, which reduced the percentage of carry-off ash. In double combustion chambers the carry-off ash amounts to 30-40%, and in the cyclone combustion chambers it is reduced to 10-15%. Since these combustion chambers are the most efficient technically and economically, and since they reduced the volume of ash discharged into the atmospheric air, they should come into exclusive use. Chambers of the layer fuel combustion type are used principally in industrial and in community residence boiler rooms, while coat-dust combustion chambers are found mostly in the boiler houses of electric power plants. Large quantities are consumed in the comparatively few boiler houses of the City's electric power plants. Boiler complexes of city electric heat and power plants are serious sources of atmospheric air pollution. This fact caused the Moscow sanitary authorities to issue a mandatory request that efficient ash catching devices be installed in all Moscow electricity generating stations, and that ash transportation from such stations to selected dumps be done in tightly enclosed conveyances. Moscow electrogenerating stations now use the following two-stage ash trapping installation: battery cyclones with electric filters, as illustrated in Figure 8, with an overall efficiency of 95-98%, and with a hydraulic ash removal; ash dumps must be located beyond the city limit.

Fig. 8



ELECTROSTATIC FILTER DVP-8TS (FOR SMOKE, VERTICAL, PLASTIC, WITH BATTERY CYCLONE)

All electrostatic filters were equipped with milliammeters and voltagemeters, which recorded the electrical parameters of their operation. Operation of purification installations was adjusted to accord with the operation of the electric power plants' basic equipment to insure operational continuity and efficiency. Workers were rewarded with bonuses for proper operation and maintenance of purification equipment, which had a salutatory effect on the workers' morale and the performance of their occupational functions. Plants' boilers and purification installations were shut down for simultaneous overhauling, after which their performance efficiency was checked, and, if found wanting, steps were taken to restore them to the levels of original rated efficiency. Boilers were not put into operation unless and until ash trapping installations were functioning normally. The ash trapped at Moscow electric power plants burning solid fuel was transferred by a hydraulic ash removal system to special ash dumps maintained in a moist condition under strict control to prevent the ashes from becoming windblown into the atmospheric air. Filled dumps were overlaid with 20-30 cm of soil and grass seeded.

A few of the elctric power generating stations used mazut as fuel the complete combustion of which depended upon a proper mazut/air ratio. All electric power station boilers were ordered to install smoke recorders or smoke meters in the form of a light installed inside the boiler aggregate gas flue or smoke stack. Changes in light intensity caused by changes in smoke intensity affected a photoelectric cell. Electric currents activated by the light changes were amplified and fed either to a galvanometer or to a microammeter having a scal: graduated into units of smoke intensity. The smoke meter was moun:ed on a panel with a system regulating the boiler operation. The latter, in turn, was connected with a 24-hour smoke intensity recording device. Actually, the fuel combustion in the boilers must be complete and smokeless, and any records pointing to the presence of smoke reflected negligence on the part of the fireman. Similar instruments have been installed at some boiler units of Moscow's electric heat and power plants which burned gas, in order to determine the extent of smoking and to prevent smoking when an infraction occurred in the process of gas combustion. This system has been introduced by the Moscow Sanitary Service; it fully served the intended purpose and was recommended to most boiler room operators.

The above described smoke recording devices were designed by Mosenergo, but their production must be mastered by the machine building industry.

According to regulations presently in force, any boiler rooms located within the city limits and consuming more than 10 t of solid fuel per day must be equipped with ash-catching installations; in fact, some boiler rooms with a fuel consumption of less than 10 t per day have such installations. Ash-catching devices have been installed in these boiler rooms due to complaints coming from persons residing in the vicinity of such plants.

Table 4

DEGREE OF ASH AND SULFUR DIOXIDE REMOVAL BY DIFFERENT BOILER HEATERS IN PERCENT ACCORDING TO YEARS

YEAR	BOILER OPERATING ELECTRIC STATIONS		BOILERS OF COMMUNAL RESIDENCES AND INDUSTRIAL ENTERPRIZES		TOTAL DISCHARGE	
	ASH	SO_2	ASH	SO_2	ASH	SO_2
1950	—	—	—	—	100	100
1953	35	41	42	50	77	91
1954	11	36	35	46	46	82
1955	11,2	31,2	30,6	47,8	41,8	79
1956	6,1	25	34,4	50	40,5	75
1957	3	12	33	54	36	66
1959	3,8	10,5	20	47,5	23,8	58
1960	3,5	9	17,9	46	21,4	55
1961	3,4	9,3	17,6	42	21	51,3

Moscow boiler rooms using layer combustion chambers have been equipped with NIIOGAZ cyclones and battery cyclones. Louver-type ash-catching units are less expensive, but they are less efficient; at present only few such units are in operation in Moscow boiler rooms. NIIOGAZ cyclones have a performance efficiency of 90% as compared with 65 - 80% efficiency of battery cyclones; their use on a broader scale is recommended, especially in remodeled old boiler rooms. In planning new medium-capacity boiler rooms provision should be made for the installation of NITTOGAZ cyclones; VTI wet scrubbers should be installed in boiler rooms of large capacity where facilities for the removal of wet sla were available.

Moscow's industrial and community boiler rooms are widely scattered over the city's territory. This makes the use of a combined system of hydraulic ash removal impossible. Therefore ashes are collected in airtight receptacles and transported to ash dumps for final disposal.

Practical application of the above recommended measures by Moscow's boiler operated plants considerably reduced the discharge of ash and sulfur dioxide into the atmospheric air of Moscow shown by data presented in Table 4. No such reduction was noted in the discharges of sulfur dioxide during the same period, due to the fact that Donets coal contained a high percentage of sulfur. Reduction in the discharges of sulfur dioxide was attained later when coal burning boilers were converted to gas burning.

Stationary Air Sample Collecting Points

The Moscow Municipal Sanitary-Epidemiological and City-District Sanitary-Epidemiological Stations have been systematically observing the city's air basin pollution at specially organized stationary points since 1954. Air samples have been collected for laboratory tests for dust, sulfur dioxide and in somce instances for carbon monoxide. These products discharged by industrial establishments, boiler rooms of residential and public buildings, and transport motor vehicles are the principal pollutants of the city's atmospheric air. A considerable part of the city's air dust was ground and industrial dust. Twenty-five stationary points are now in operation in Moscow. Air samples are collected by aspiration at regional points twice a week on specified days and hours, and daily at the municipal stationary points at the same hours. Dust content is determined gravimetrically and sulfur dioxide nephelometrically. More than 15,000 samples of atmospheric air are collected and analyzed annually at the stationary points. Analytic data are evaluated for each collection point on the basis of average monthly atmospheric pollution by dust and sulfur dioxide expressed in terms of milligrams per cubic meter.

In accordance with the specific general planning and construction of Moscow, special sections have been classed characterized by a predominance of monotypical air pollution, such as industrial, highway, residential, vegetation, etc. Stationary air sample collection points had been organized in industrial districts the pollution discharges of which permeated into residential blocks located at some distance from the industrial establishments close to highways with intensive auto-transport traffic, in the proximity of railroad stations, and in the city parks. Highest concentrations of SO_2 were found in air samples collected at stationary points located in the industrial districts, and lowest in samples collected in the city parks. Air of residential districts showed generally a lower pollution level where industrial establishments were absent. However, location of industrial enterprises in residential districts without the provisions of sanitary protection zones introduced considerable pollution into the atmospheric air of individual residential sectors. A high air dust content prevailed the year round on highways with intensive auto-transport traffic. Diesel fuel exhaust, boiler room fumes, and industrial establishments located close to highways constituted serious sources of air pollution with sulfur dioxide.

The atmospheric air of sections close to railroad stations was also characterized by high content of sulfur dioxide and dust which may have been the result of incomplete coal combustion in the locomotive burning chambers, and discharges coming from the depot, the railroad workshops, etc. Considerable dust was created by the intensive auto transport, by the pedestrians, etc.

Air samples collected at the stationary point on the 8th floor of hotel "Leningradskaya", located in the railroad station zone, showed a low dust concentration and a high concentration of sulfur dioxide, indicating that SO_2 polluted atmospheric air at altitudes far above the breathing level; analytical results indicated that the cleanest air was found in parks and other similar city spots. Laboratory data also showed that air dust concentration persisted at high levels at all seasons of the year in 1956. Beginning with 1957 air dust content has been falling in the winter and rising considerably in the summer months. It is believed that the high air dust content in the winter of 1956 may have been due to a high rate of solid fuel consumption at that time, and to low efficiency air purifying installations.

In 1957 - 1958 a new complex of sanitary measures was adopted for the protection of the city's atmospheric air against pollution; consumption of solid fuel was drastically reduced by converting coal burning chambers partly into gas and partly into liquid fuel combustion furnaces. Such measures reduced Moscow's air pollution to a considerable degree. Thus, in the industrial zone the average yearly air dust density fell from 0.99 mg/m^3 in 1956 to 0.35 mg/m^3 in 1962; in the residential zone the drop was from 0.75 to 0.27 mg/m^3; on the highways - from 0.89 to 0.22 mg/m^3;

in the railroad station zone from 0.82 to 0.46 mg/m^3, and in the areas of parks from 0.63 to 0.1 mg/m^3.

Since 1957 a considerable reduction in air dust density was noted in the winter and a rise in the summer months. An investigation of the observation had shown that Moscow's atmospheric air dust pollution came not only from furnace discharges, but basically from ground surface dust raised by winds and transport traffic, especially in the case of poorly paved streets and highways, etc. Table 5 shows average dust-densities according to seasons from 1956 through 1962.

Table 5

MG OF AIR DUST PER M^3 OF AIR. SEASONAL AVERAGES

Nature of local region	1956		1957		1958		1959		1960		1961		1962	
	Season of year													
	Heated	Non-heated	Heated	Non-heated	Heated	Non-heated	Heated	Non-heated	Heated	Non-heated	Heated	Non-heated	Heated	Non-heated
Industrial	0,98	1,0	0,37	0,44	0,36	0,45	0,28	0,4	0,25	0,45	0,3	0,39	0,22	0,3
Residential	0,74	0,67	0,22	0,34	0,25	0,28	0,23	0,3	0,25	0,32	0,24	0,34	0,2	0,36
Highways	0,77	0,97	0,4	0,68	0,64	0,71	0,47	0,92	0,11	0,33	0,35	0,43	0,28	0,51
Railroads	0,6	0,96	0,3	0,38	0,22	0,32	0,35	0,41	0,39	0,54	0,12	0,13	0,18	0,18
Parks	0,59	0,66	0,11	0,14	0,17	0,22	0,09	0,14	0,1	0,11	0,23	0,22	0,18	0,18

Table 6

MG OF SULFUR DIOXIDE PER M^3 OF ATMOSPHERIC AIR. SEASONAL AVERAGE

Nature of local region	1956		1957		1958		1959		1960		1961		1962	
	Season of year													
	Heated	Non-heated	Heated	Non-heated	Heated	Non-heated	Heated	Non-heated	Heated	Non-heated	Heated	Non-heated	Heated	Non-heated
Industrial	0,84	0,82	0,5	0,28	0,37	0,24	0,37	0,21	0,31	0,19	0,24	0,22	0,4	0,25
Residential	0,84	0,51	0,53	0,37	0,28	0,13	0,34	0,19	0,23	0,14	0,28	0,16	0,25	0,14
Highways			0,52	0,3	0,52	0,13	0,46	0,27	0,51	0,3	0,89	0,34	0,29	0,2
Railroads	0,78	0,68	0,5	0,29	0,56	0,22	0,5	0,38	0,48	0,23	0,31	0,16	0,31	0,18
Parks	0,78	0,7	0,34	0,17	0,6	0,2	0,14	0,04	0,16	0,06	0,14	0,11	0,24	0,17

An inverse relationship was observed with respect to the atmospheric air pollution with sulfur dioxide seasonally: air pollution by sulfur dioxide was higher during the winter heating than during the summer months when most of the boiler rooms ceased to operate. Table 6 lists average indicators of atmospheric air pollution with sulfur dioxide according to seasons from 1956 through 1962. Extensive conversion of industrial establishments and large boiler rooms of community facilities to gas burning considerably reduced atmospheric air pollution by sulfur dioxide in 1957 as compared with 1956. The reduction was noted at all stationary air sampling points, and for the city in general. Reduction in Moscow air pollution was noted also in the succeeding years, although to a considerably lesser degree; due to an insufficient gas supply to Moscow, the rate of conversion to gas burning was lowered considerably, and many large industrial plants were operating during part of the year on solid and liquid fuel. A notably sharp reduction in atmospheric air pollution by sulfur dioxide was observed in many city districts during the warm season, when electric heat, light and power plants operating in the summer received adequate supplies of gas. The average annual intensity of the atmospheric air pollution by sulfur dioxide, as compared with 1956, was reduced in 1962 in the industrial zone from 0.81 to 0.24 mg/m^3, in the residential zone from 0.66 to 0.18 mg/m^3, in the railroad station zone from 0.75 to 0.35 mg/m^3, in the vegetation implanted zone from 0.74 to 0.11 mg/m^3, and for the city as a whole the SO_2 dropped from 0.74 to 0.25 mg/m^3, and the dust density from 0.81 to 0.36 mg/m^3.

The improvement in the quality of Moscow atmospheric air reflected the favorable effects of the enacted air health measures and, in particular, the strict sanitation regulations, the conversion of hard and liquid fuel burning furnaces to gas combustion, and the systems of parks, groves, etc.

ASPIRATION APPARATUS FOR COLLECTING ATMOSPHERIC AIR SAMPLES

USSR technologists, inventors and scientists have recently accelerated the tempo and broadened the scope of developing new equipment, and new technological processes characterized by high efficiency, productivity and automation; this considerably improves human working conditions. In this connection the introduction of automatically operating installations for the collection of atmospheric air samples substantially reduces experimental errors, makes the laboratory worker's task easier, thereby increasing the number and accuracy of analyses, etc. The automation method of collecting air samples whether single or at intermittent intervals, freed the laboratory workers from performing this simple procedure. Reliable hygienic evaluation of air pollution requires that samples be taken 24 hours round the clock. Air samples collected at night, when the plant's purification installations may not be operating, are of particular importance.

Air sample collection at night can now be attained early by using automatic air sampling devices. New air aspirators functioning automatically and manually, have been developed by engineer L. F. Kacher of the Sanitary-Epidemiological Station of Moscow, which are now in production. The air aspirators have been approved by the Committee on Sanitary Protection of the Atmospheric Air affiliated with the Main Sanitary Epidemiological Administration of the USSR Ministry of Health.

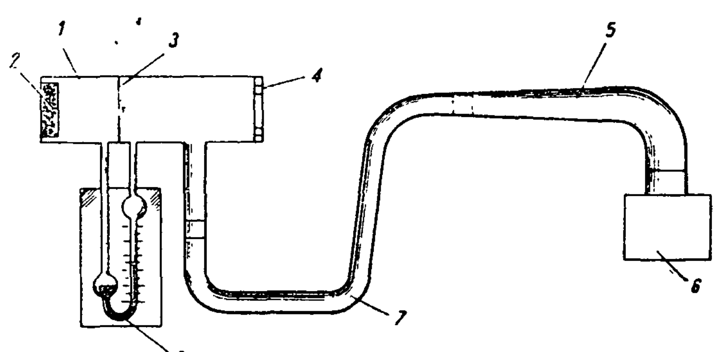
Aspiration apparatuses used in atmospheric air research can be classed into the following two groups; those operating with the aid of local energy sources, and portable aspirators operating with the aid of built-in batteries. Aspirators of the first group are usually employed in conducting atmospheric air pollution studies at stationary air sample collection points. Aspirators of the second type are employed in conducting atmospheric air pollution studies at temporarily selected points of special interest where electric energy is not available.

In designing aspirators used at other than stationary points consideration was given to the fact that dust density studies required the aspiration of large atmospheric air volumes in order to be able to register gravimetric increase increments. In addition, a change in the wind direction may require frequent changing of the sample collection point possible only with easily portable equipment.

THE AUTOMOBILE ASPIRATOR

The automobile aspirator belongs to equipment of the second group and is used for the collection of special atmospheric air samples. An automobile motor is used as the energy source and as a means of transportation. An automobile aspirator functions steadily and with sufficient reliability. The aspirator is attached to the automobile engine with no design changes, directly to the carburetor intake connection, and the work is performed with the engine in the state of idling as shown in Fig. 9.

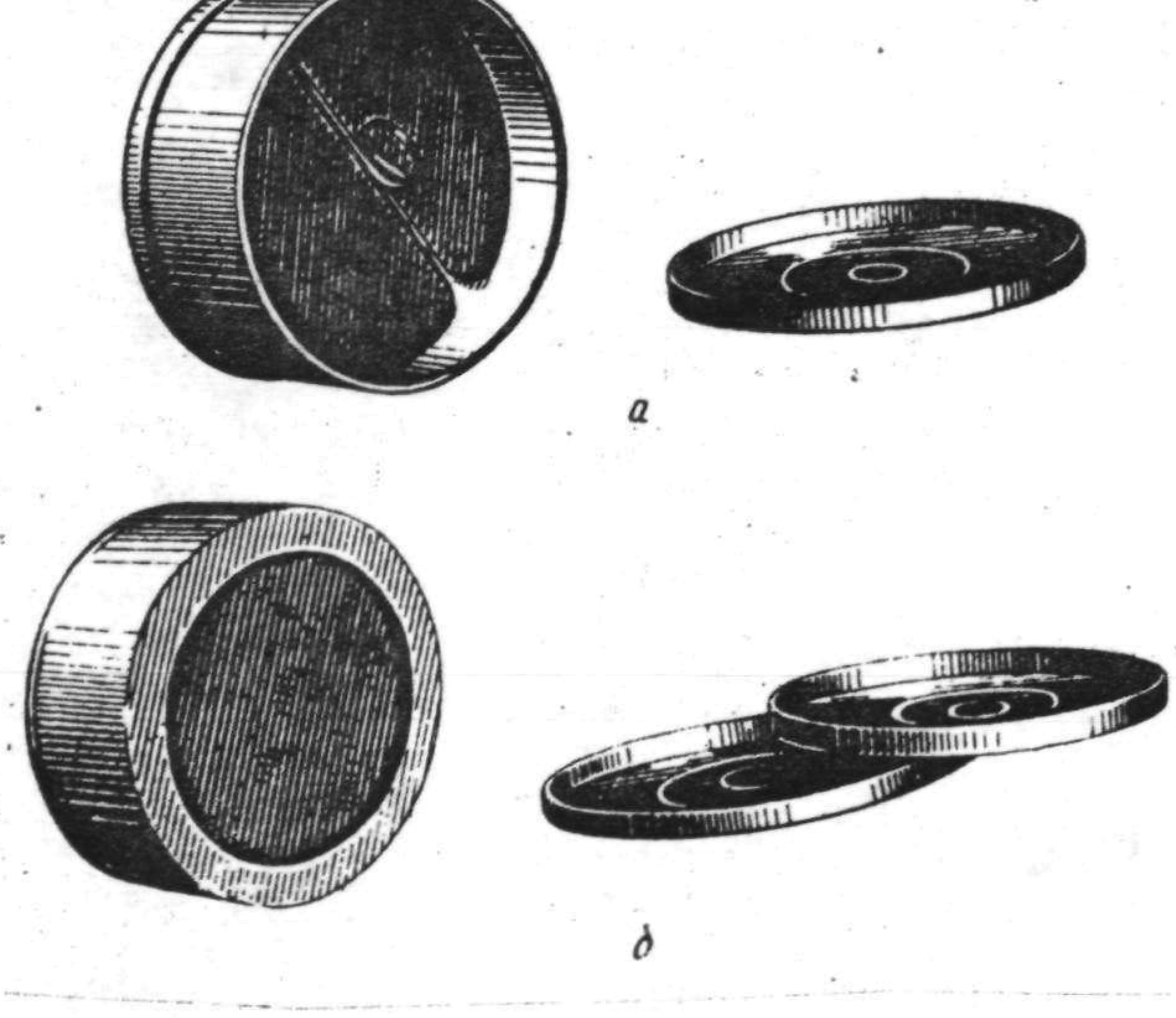
Fig. 9



SCHEMATIC PRESENTATION OF THE AUTOMOBILE ASPIRATOR
1 - BUSHING; 2 - RECEPTACLE (PATRON); 3 - DIAPHRAGM; 4 - PERFORATED DAMPER; 5 - ELBOW; 6 - CARBURETOR; 7 - 20 MM RUBBER TUBING; 8 - FLOWMETER.

The automobile air aspirator can be attached to any motor vehicle operating on 4 or more cylinders. The tested air is drawn through a metal adapter fitted with a cotton or Petryanov fabric absorber. The metal adapter is a duraluminum cylinder, into which the adsorbent material is inserted as shown in Figure 10. The automobile aspirator efficiency is determined with the aid of formula ($Q = A \sqrt{P}$,) where Q is the productivity expressed in liters of air per minute, P is the pressure drop in terms of millimeters of water column, and A is a constant determined and specified by the aspirator manufacturer. The aspirator has several nipples of varying diameters. The automobile air aspirator is operated as follows: the vehicle is stationed at a selected point based on wind direction; the aspirator is connected to the carburetor, the wind velocity is determined by an anemometer; the required nipple diameter is determined from a graph, the metal adapter is set into place, the required pressure differential is determined by a flowmeter attached to the carbureter throttle, or to the aspirator, and the air sample taking begins. The aspirated dust is determined gravimetrically in the laboratory by a standardized method. The automobile air aspirator has been carefully tested and found efficient in practical operation, and is recommended for use in investigating atmospheric air dust density.

Fig. 10

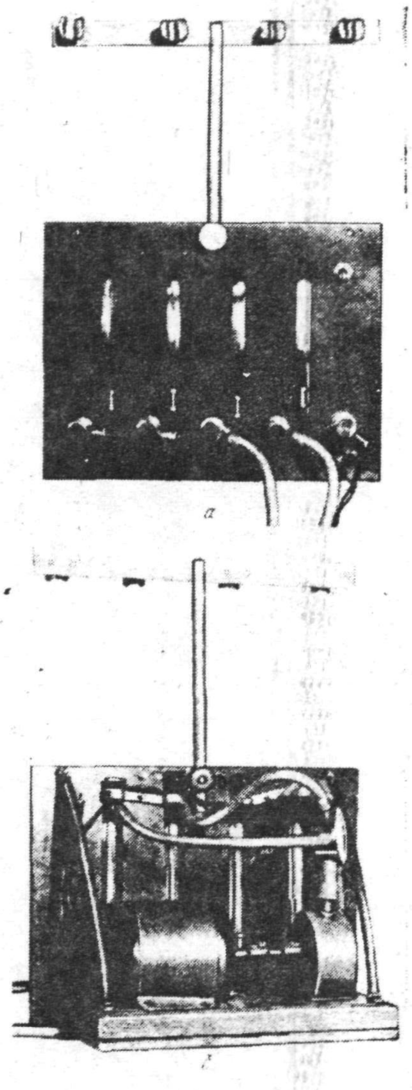


METALLIC HOLDER FOR AUTOMOBILE ASPIRATOR
A - FRONT VIEW OF OPEN HOLDER; B - REAR VIEW OF SAME

ELECTRICAL ASPIRATOR LK - 1

Electric aspirator LK-1 belongs to the second equipment group. A 12-v battery is used as the source of energy. Photographs of aspirator LK-1 are shown in Fig. 11. Atmospheric air samples are collected by aspirating the air through absorbers at a definite rate. The instrument is provided with an air blower, flowmeter for measuring the rate of air flow under regulated conditions. The air volume passed through the adsorber is determined on the basis of rate of flow and aspiration time.

Fig. 11



ASPIRATOR LK-1
UPPER - FRONT VIEW; LOWER - INSIDE VIEW

The aspirator is designed for operation by a 12-v battery. The power consumed by the instrument amounts to approximately 55 w. The direct-current motor develops 3000 rpm. Four air samples are collected at a time. The flowmeters are designed for a maximum flow rate of 0.5 li/min. The permissible error of the flow meters is ± 10%. All subassembly terminals of the apparatus are fastened to a panel. The apparatus consists of 4 flowmeters, 5 operating regulators, 5 absorber connecting sleeves, an apparatus switch, an absorber fastening support, an air blower, an electric motor, an air collector, and a bulb for illuminating the scale.

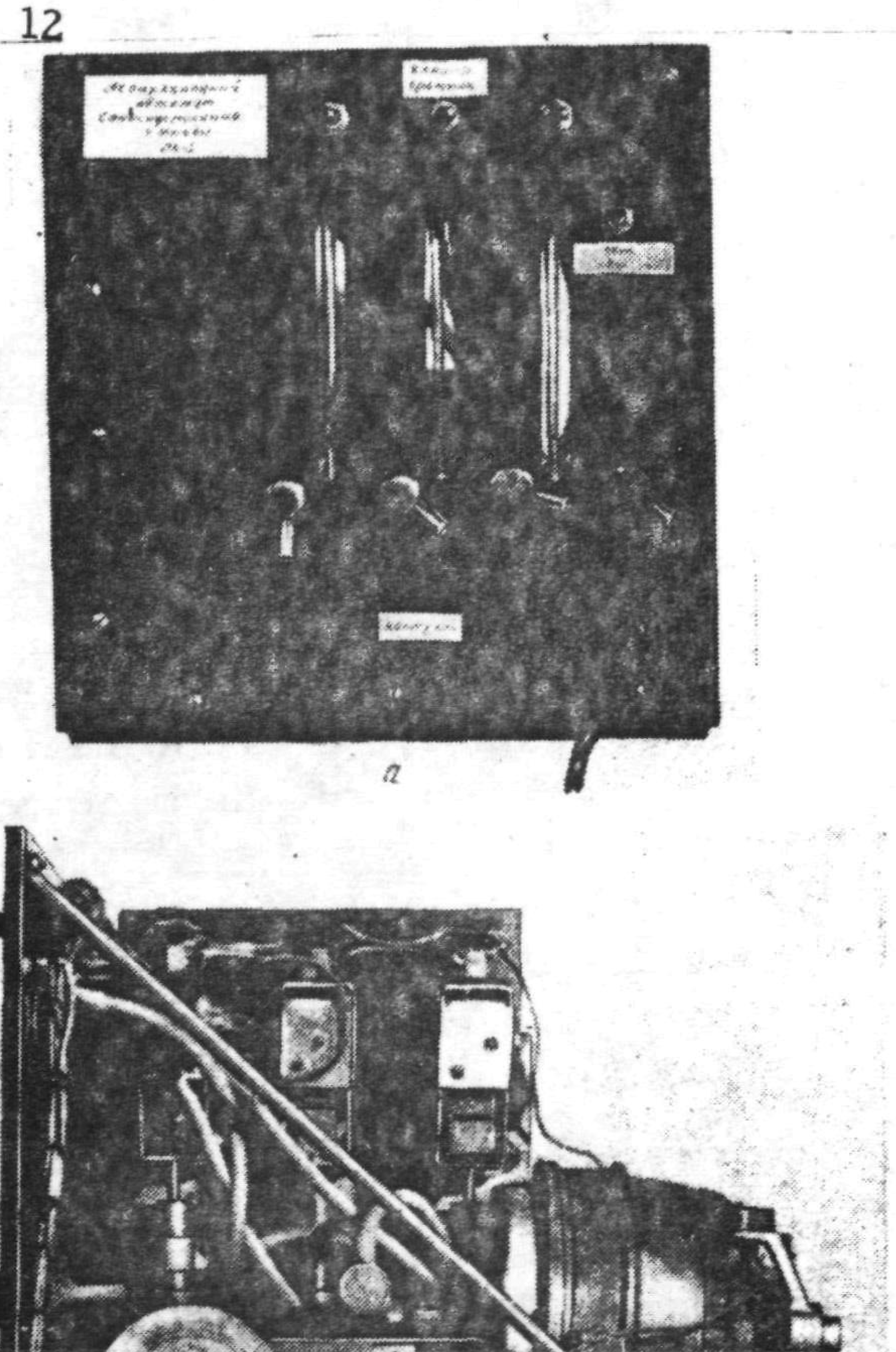
The aspirator is put into operation according to the following sequence of steps: the operation regulators are shut off; the absorbers are joined to the connecting branches by means of rubber tubing; the apparatus is switched on, and the required aspiration rate is selected by manipulating the operation regulators. The apparatus is designed for repeated 40-minutes continuous operation with 5-10 min. rest intervals. Aspirator LK-1 is easily portable, can be installed on any motor vehicle, and can be connected to its battery. With the aspirator installed on a motor vehicle as described, air samples can be collected in motion in a specifically polluted area near a production plant, in a street, or in a block. To insure normal operation of the air aspirator, the electric-motor bearings and the air blower must be lubricated with GOST (State Standard) 928-53 machine oil at the rate of one drop per 40-60 minutes. It is recommended that the air blower be washed with kerosene every 10 - 15 hours and its housing be lubricated.

For this the frame must be removed from the box and the oil pipetted or otherwise forced into the lubricating bearing housing.

THE AUTOMATIC ELECTRICAL ASPIRATOR LK-2

Automatic electrical aspirator LK-2, shown in Figure 12, belongs to the second group of aspirators operated by locally available electric energy. The instrument is designed for the collection of individual atmospheric air samples. It operates on the basis of a specific program automatically. It is illustrated schematically in Figure 13. The operating program of the instrument can be selected as desired by adjusting the time relay. The present instrument design permits automatic air sample collection at 7 a.m., 5 p.m., and at 12 midnight. In addition, samples may be collected by the instrument at intervals of 12 and 5 hours. The instrument is installed on a stationary basis for a specified period at some air sampling point provided with a 220-v electric power supply. The instrument is mounted on an angular panel installed in a wooden box. It consumes approximately 300 w of power.

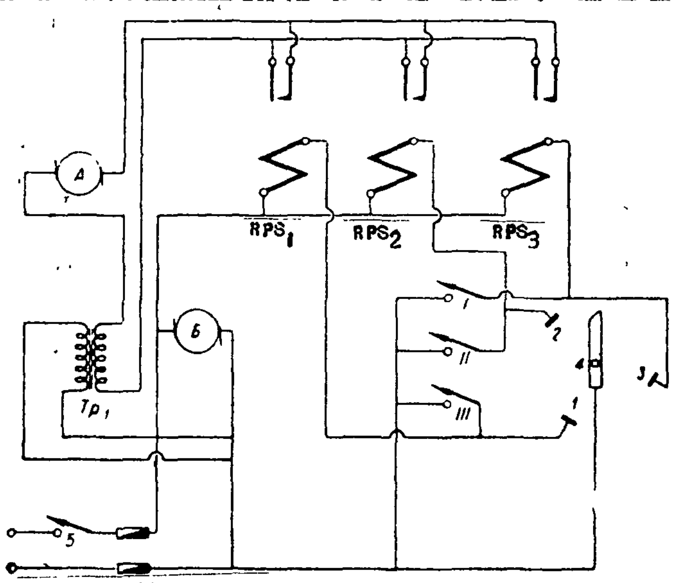
Fig. 12



AUTOMATIC ELECTRICAL ASPIRATOR LK-2
UPPER - FRONT VIEW; LOWER - INSIDE VIEW

When the instrument is connected to the power network, a bulb lights up and the motor of the time relay begins to operate. The absorbers are connected to the operation regulators by means of rubber tubing with the cocks of all regulators safely closed. For channel adjustment, each line is in turn put into operation according to a specific rate of air-sample selection; at this point the air impeller begins to operate, and one of the three valves opens. The required air aspiration is attained by means of the operation regulator, and the adjustment switch is turned off. The other two time channels are adjusted in the same manner. It must be remembered that no re-adjustment may be made on the regulators once the apparatus has been adjusted. The time relay is adjusted next. The time relay disk is divided into 24 equal parts and, when the locking clasp is disengaged, the disk can be turned about its axis. The time-relay disk is set so that the number of divisions fronting the next operating contact equals the number of hours preceding the next instrument switching on; the disk is then fastened with the locking punch cock.

Fig. 13



SCHEMATIC PLAN OF ASPIRATOR LK-2 (LK-2)
A - AIR IMPELLER MOTOR; B - TIME RELAY MOTOR; RPS_1, RPS_2, RPS_3, - SLAVE RELAYS; I, II, III - MANUAL ADJUSTMENT; 1, 2, 3, 4 - AUTOMATIC OPERATION; 5 - APPARATUS SWITCH

This procedure completes the preliminary preparation of the apparatus for operation. Air samples are collected at 7 p.m., 12 midnight, and at 7 a.m. in different adsorbers. Collection of a single sample consumes 20 minutes. Between 7 a. m. and 7 p.m. the absorbers must be replaced by new ones and the operation regulators must be adjusted; the time relay setting remains unchanged.

Individual air samples must be aspirated through each channel. The air volume aspirated through the absorbers is determined with the aid of the following formula:

$$Q = 20\ li$$

where Q is the total liters of air aspirated through the absorber;

20 is the time constant of air aspiration in minutes;

li is the established rate of air aspiration in liters per minute.

In special cases it may be desirable to connect extra aspirator absorbers intended for special determination of some chemical components.

This can be done with the instrument here described. It is possible, when necessary, to connect more absorbers to the instrument for the fractional collection of an average daily sample during three 20 min. intervals. Air volume passed through such absorbers is determined by the following formula:

$$Q = 60\ li$$

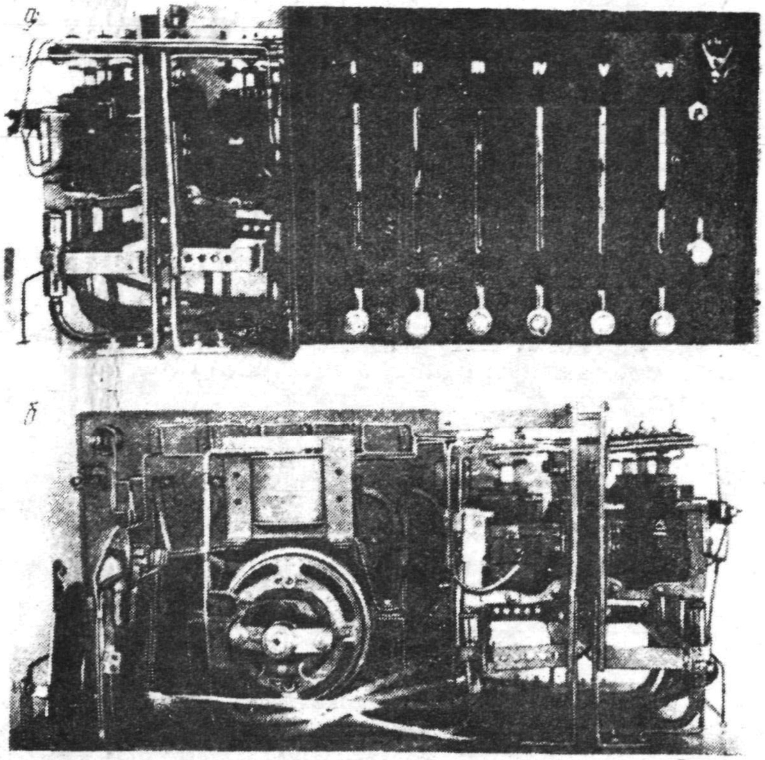
where 60 is the time constant for collecting the sample during three 20 minute periods.

In addition to operating automatically, the new air aspirator permits the simultaneous collection of 4 air samples when the time relay is disconnected. In such a case the air is aspirated at a given rate for a predetermined time. Proper function of the instrument requires that its essential parts, such as the gear mechanism of the time relay and also the valve rods, be lubricated once a week.

AUTOMATIC ELECTRICAL ASPIRATOR LK-2A

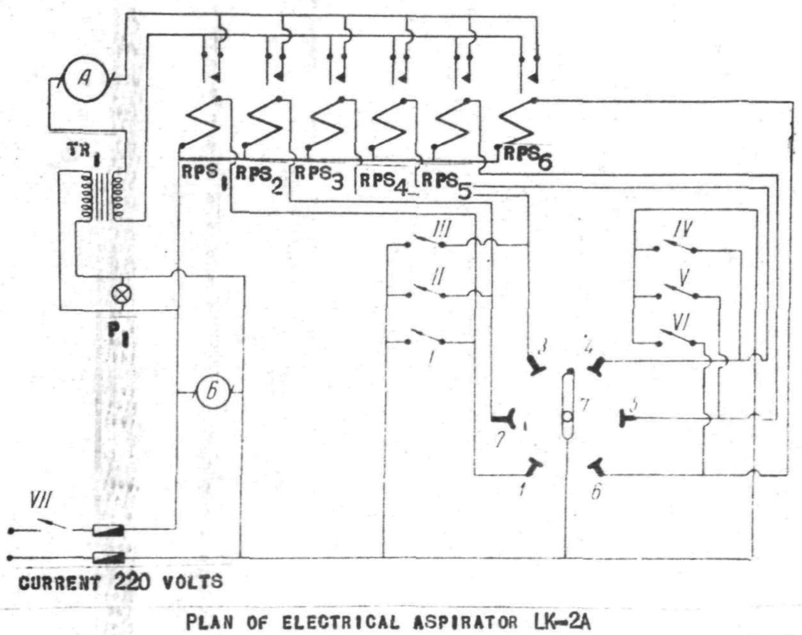
This automatic electric aspirator is photographically illustrated in Figure 14. It was designed for the collection of individual atmospheric air samples. It may also be used for taking air samples inside industrial premises. The instrument operates automatically according to a specified program without human participation. It is installed at a fixed point for a specified time, it powered by a locally available 220-v alternating current, and consumes approximately 300 w of electricity. The apparatus is mounted on an angular panel inclosed in a wooden box; it consists of the following principal suba semblies: an air impeller with a synchronous electric motor, a time relay, a group of valves, a group of actuating relays, volumetric apparatus, an operation regulator, and manual adjustment switches. The electric motor of the air impeller is put into operation by an actuating relay shown in Figure 15, which is connected to the time relay. The air impeller operates for 10 minutes, and is then turned off. The instrument is programmed to switch in 6 times in 24-hours at 4-hour intervals. The air impeller is switched on at 8 a.m., 12 noon, 4 p.m., 8 p.m., 2 a.m. and 6 a.m., or respectively at other hours at similar equal intervals. The starting operation time can be altered by moving a special slide. Time between the instrument's operation intervals may also be changed. The instrument has 6 valves which can be opened by means of actuating relays and, when the instrument is switched off, can be closed by the action of a back-moving spring located inside the valve case. The valves' inlets and outlets have an internal diameter of 6 mm.

Fig. 14



AUTOMATIC ELECTRICAL ASPIRATOR LK-2A
A - FRONT VIEW; B - INSIDE VIEW

Fig. 15



PLAN OF ELECTRICAL ASPIRATOR LK-2A
A - AIR IMPELLER MOTOR; B - TIME RELAY MOTOR; RPS - SLAVE RELAYS I-VI - MANUAL OPERATION ADJUSTMENT; L,2,3,4, - AUTOMATIC OPERATION 5 - APPARATUS SWITCH

The air valves are connected by means of rubber tubing with a collector installed at the suction end of an exhaust fan, and by way of the flowmeter fan intake and, by way of rotometers, and with the operation regulators. Each air channel has its own flowmeter of a capacity up to 3 liters per minute, and an operation regulator which makes possible the use of absorbers having different pressure drops and, when necessary, different absorber solution volumes. The apparatus is set into operation as follows: the time to begin air sample collection is determined by the position of the time-relay slider; the apparatus is switched into the electrical power network which starts the time relay operation. Before the apparatus functioning is started all operation regulators must be closed, and the selected absorbers must be joined to the connecting pipes. The required air flow rate through the absorbers is attained by gradually turning on and then turning off the air adjustment switches, while the respective operation regulators are being opened. The apparatus should be adjusted 30-40 minutes before the air aspirator is set into operation by the automatic switching system. The adjusted apparatus will automatically aspirate 6 samples in the course of 24 hours. If necessary an additional absorber can be connected by way of an outside flowmeter to the connecting pipe of the seventh operation regulator.

Such apparatus design makes possible the simultaneous aspiration of 7 air samples for the determination of 7 different pollution ingredients, at 7 differential points in a shop by switching the apparatus on manually. For this, the required rates of air aspiration through the 7 absorbers are simultaneously adjusted by the operation regulators, and the air samples are aspirated in the course of the required time interval. The amount of air aspirated through the first 6 absorbers is determined correspondingly for each absorber by the following formula:

$$Q = 12\ li$$

where Q is the volume of air in li which was aspirated through the absorber; 12 is the aspiration time constant in minutes; and li is the established air aspiration rate in liters per minute.

The volume of air aspirated through the 7th absorber is determined by the following formula:

$$Q_7 = 12\ li\ 7n$$

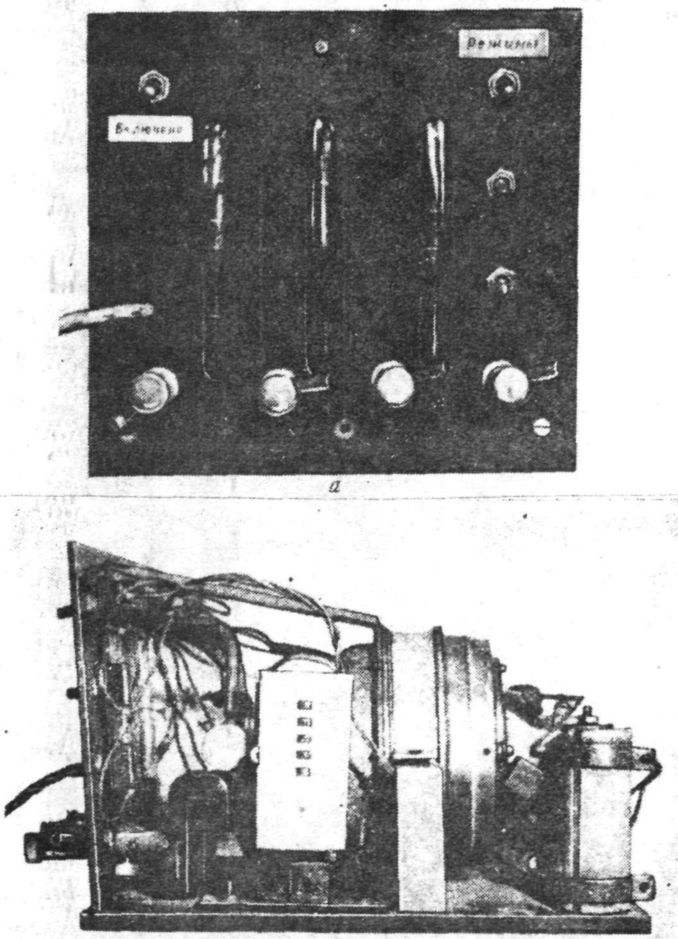
where n is the number of times the instrument was switched in for 12 min. aspiration intervals through absorber 7 for the collection of an average 24 hour air sample.

The vital parts of aspirator LK-2A must be thoroughly lubricated weekly to insure proper instrument operation.

AUTOMATIC ELECTRICAL ASPIRATOR LK-3

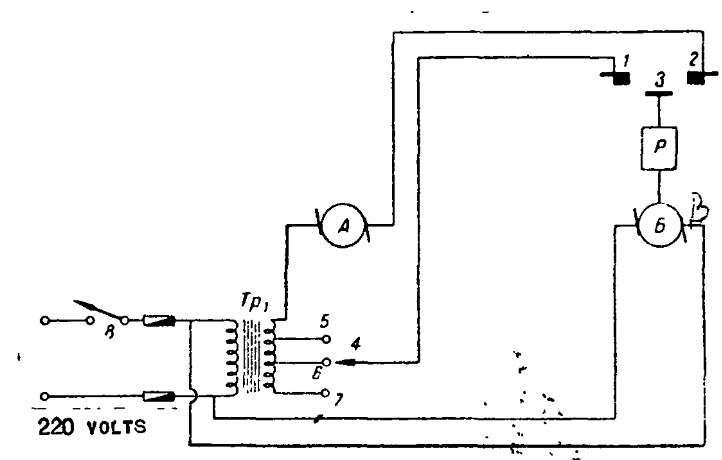
The automatic electrical aspiration LK-3 shown in Figure 16 belongs to the first group of aspirators and operates on alternating-current. It was designed for the aspiration of average 24-hour atmospheric air samples. The aspirator operates automatically according to a specific program. It is schematically illustrated in Fig. 17. Three samples are aspirated simultaneously. In the course of 24 hours the instrument is turned on hourly for 30 minutes. The instrument functions under several sets of operating conditions, depending upon the pressure drop developed by the absorber material used. The number of times the apparatus has been switched in automatically is registered by special counter, and is used in computing the total amount of aspirated air. The instrument is installed at a stationary point. An alternating current of 220 v supplies the power to the instrument which consumes approximately 300 w. The instrument is mounted on an angular panel enclosed in a wooden box.

Fig. 16



AUTOMATIC ELECTRICAL ASPIRATOR LK-3
TOP - FRONT VIEW; LOWER - INSIDE VIEW

Fig. 17



ELECTRICAL PHASE OF ELECTROASPIRATOR LK-3 (LK-3)
A-MOTOR OF AIR IMPELLER; B-TIME RELAY MOTOR; P-OPERATING MECHANISM OF THE TIME RELAY; 1,2,3, - AUTOMATIC ADJUSTER, 4,5,6,7 - VOLTAGE REGULATION; 8 - SWITCH

When the instrument is switched into the power line, an electric bulb lights up and the time-relay motor starts. The absorbers are fastened by means of rubber tubing to the cocks of the operation regulators. The required air aspiration rate is attained by manipulating adjustment screws, which completes the instrument adjustment. Subsequently the instrument operation is controlled automatically by the time relay. The absorbers can be set to operate at any desired time intervals.

Tp - transformer; a) 220 v network

The total amount of air aspirated through the absorbers is computed by the following formula:

$$Q = 30 \text{ li } n$$

where Q is the air volume in liters aspirated through the absorbers;

30 is the air aspiration time constant in minutes;

n is the number of times the instrument has been switched in;

li is the determined air aspiration rate in liters per minute

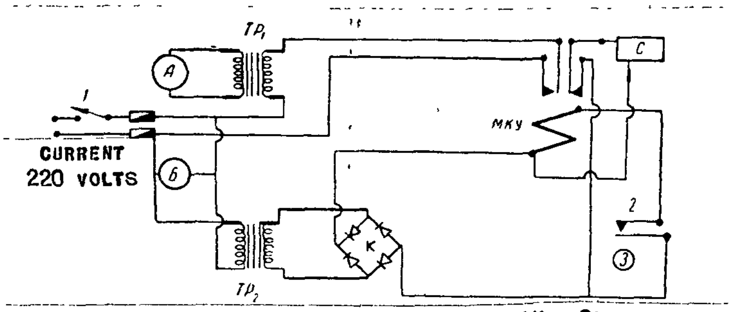
When necessary an additional absorber may be attached by way of a supplementary flowmeter connected to the fourth operation regulator.

The essential parts of this aspirator must be lubricated weekly as previously described for other aspirators.

AUTOMATIC ELECTRICAL ASPIRATOR LK-3A

Automatic electrical aspirator LK-3A, schematically illustrated in Fig. 18, is intended for the collection of 24-hour average atmospheric air samples for determining concentrations of dust or other suspended particulates. It belongs to aspirators of group I. The instrument operates automatically according to a specified program without human participation. Filters made of ACA-B-18 (untransliterated) Petryanov' fabric are used in this type of air aspirators. The instrument is installed for a specified time at a selected fixed point. An alternating current of 220 v serves as the source of power supplied to the instrument, which consumes approximately 270 w. The apparatus is mounted on an angular panel enclosed in a box, and consists of the following principal subassemblies: an electrically operated air blower, a time relay with a counter which recorded the number of times the aspiration has been switched in, and a volume recording device and operation regulators.

Fig. 18



ELECTRICAL PHASE OF ELECTROASPIRATOR LK - 3A
A - AIR IMPELLER MOTOR; B - MOTOR OF TIME RELAY; K - COPPER OXIDE RECTIFIER; C - SWITCHING OFF METER; TP_1 - STEP-DOWN TRANSFORMER; TP_2 - TRANSFORMER OF COPPER OXIDE RECTIFIER; 1 - APPARATUS SWITCH; 2 - CONTACTS OF TIME RELAY; 3 - TIME RELAY

To prevent undue motor wear and thereby assure reliable apparatus performance, the electric motor should be operated on reduced voltage obtained with the aid of AOS-03 220/127 v step-down transformer. The electric motor of the air blower is switched in by means of the time relay. The blower operates for 2.25 minutes, and is then switched off for 2 minutes. Such an operating schedule was adopted to prevent the instrument from overheating and to secure maximum air volume aspirated through the apparatus. The instrument is switched in 340 times in 24 hours. A diagram of the instrument is shown in Fig. 18. The time relay is equipped with an electromagnetic counting mechanism which records the number of times the instrument has been switched in.

A flowmeter of 20 li/min. maximum capacity records the volume of aspirated air; it is connected by way of the collector with the fan air intake and the Y-shaped operation regulator. The instrument has another operation regulator connected by way of the collector with the intake fan air. The apparatus is set up for operation in the following manner; the instrument is installed at the selected point and is connected to the electrical supply system. The loaded absorber is connected to the operation regulator by a rubber tubing; when necessary two loaded absorbers can be connected by way of a supplementary flowmeter; the apparatus is then set into operation at the desired air flow rate continuously for 24 hours. The total volume of air aspirated through the absorbers is determined by the following formula:

$$Q = \frac{2.25\ li\ (n_2 - n_1,}{1000}$$

where Q is the total air volume aspirated through the absorber in m^3; 2.25 is the air aspiration time constant, in minutes; li is the rate of air aspiration in liters per minute; n_2 is the number of switch-ins registered by the counter at the end of air aspiration; n_1 is the counter reading at the beginning of the operation.

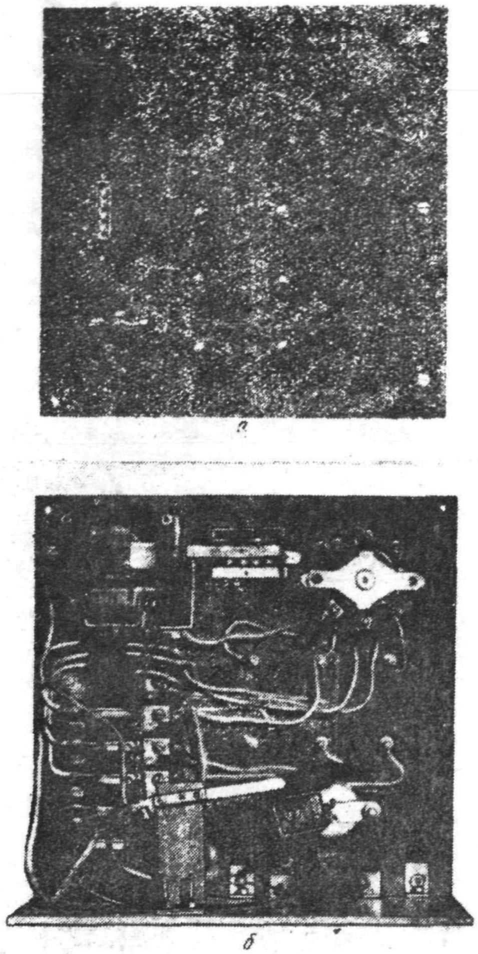
The apparatus should be lubricated weekly as previously described for other aspirators.

AUTOMATIC ELECTRICAL RELAY LK-4

Automatic electrical relay LK-4, shown in Figure 19 makes possible the use of conventional electrical aspirators powered by an alternating-current for the automatic aspiration of average 24-hour air samples without human participation. With the aid of such a relay, it is possible to use dust suction and other types of electrical aspirators which normally tend to overhead with prolonged continuous operation. With the aid of this relay, the aspirators can operate repeatedly 30 minutes at a time with intermittent 30 min. cooling off periods. The volume of air aspirated through the air absorber is computed using the formula cited in describing the LK-3 aspirator.

Two- or three-phase current, depending on the type of current required for the connected apparatus, is fed into the terminals of the electrical relay installed on the instrument panel. The employed aspirator or dust suction apparatus is connected to the inside terminals. The automatic relay is engaged by means of a special band switch; from then on all work will proceed automatically for any desired length of time. The instrument is stopped by turning the band switch. The essential parts of the apparatus must be kept clean and lubricated as previously described for other aspirators.

Fig. 19



AUTOMATIC ELECTRICAL RELAY LK-4
UPPER - FRONT VIEW; LOWER - INSIDE VIEW

THE SYSTEM OF CITY TREE PLANTING

It has been well recognized now that extensive city tree planting favorably affected the general sanitary condition of urban life. There is sense to the popular sayings that massive tree plantings, tree groves and parks are natural "oxygen factories" and "lungs of cities". Through their leaves tree absorb CO_2 and release O_2 during the day; they also release into the air considerable quantities of vaporized moisture which has a cooling effect on the surrounding air temperature; tree leaves also absorb a considerable amount of dust and noise. Green crowns of trees and shrubs also lower the velocity of winds. This is particularly noticeable in the summertime when the wind in the forest or in parks is reduced to a standstill. Expressly for this reason small forests are cultivated in extensive windy Russian steppes which considerably reduce the effect of the dry steppe winds. Reduction in air movement velocity also enhances the rate of air suspended dust settling. It has been shown that gardens and parks cultivated in the vicinity of industrial establishments lowered the local air dust density by 40% or more. Dust precipitating from the atmospheric air is retained by tree crowns, surfaces of tree trunks, and their branches to varying degrees. The rough surfaces of elm tree leaves entrap six times as much dust as do the smooth leaves of the poplar, the linden, and the aspen.

A study of dust retention by leaves of different tree species, expressed in terms of milligrams per square meter of surface yielded the following data: elm - 3.39, lilac - 1.6, linden - 1.32, maple - 1.05, poplar - 0.55.

Taking into account the dust-protective effect of leafy type of vegetation it is possible to attain a considerable reduction in the air dust density in residential areas. Areas of arborous implantation are also of significance in the abatement of city noises. Crowns of city trees absorb up to 20% of the sonic energy incident upon them, reflecting and dispersing another 74%. It has been established that at a level of 2 m above the ground surface noise intensity in a street with multistory buildings and barren of trees is 5 times as great as in a street with an abundance of trees along the sidewalks. In parks and gardens, scattered groups of trees offer better protection against noise than trees arranged in rows. Noise is absorbed most by low trees with broad crowns in combination with shrubbery beds. Trees planted between city blocks are of great psychohygienic value since they appear to be in more intimate contact with the city residents, bringing nature, so to speak, close to their doorsteps.

Trees should be transplanted when they are 8 - 11 years old, and they should be transplanted 5 years before construction begins in a new development. This is not the general practice; in most instances nursery trees are transplanted into new developments at the last moment before the houses are opened for occupancy. This is frequently done in an unplanned manner and without the cooperation of authority which originally planned the development. Furthermore, the representative of the administration in charge of municipal parks seldom participates in the inspection of a completed city development.

Unfortunately, the tendency to erect new dwellings on lots in a more efficient utilitarian manner frequently encroach upon the area intended for home garden plots. According to recent standards 1/3 of a new territory must be reserved for parks, squares and interblock trees and shrub implantations; but this standard requirement is seldom observed. In addition, official data indicate that 30-40% of trees in newly planted areas fail to survive. Poorly organized care and maintenance systems result in early destruction of new vegetation implantations. Low trees and shrubs are harmed by rotary snow removal, by the use of salt on city sidewalks, etc. Snow sliding from roofs frequently deforms tree crowns.

Municipal inspection employees and architectural planning authorities seem to forget that by the present building construction method a multistory house can be built in a few months, while 15 years is required for the full development of a shade tree. Individual trees, and frequently whole tree groves are cut down in sections where new residential developments are planned. Data of the Administration of Forest and Park Facilities in Moscow indicate that approximately 80,000 trees and 180,000 shrubs had been cut down in connection with new development and other construction operations. The ratio between parks, groves and individual tree implantation and increase in urban population is progressively becoming smaller.

The situation is similar, though not as pronounced in Moscow, despite the fact that the increment of green area in the city has been increasing. For example, 198 hectares of vegetation had been planted in 1959, - 480 hectares in 1960, 655 hectares in 1961, and 707 hectares in 1962. The Moscow territory is equal at present to 87,500 hectares, of which 18,700 hectares are given to green areas. But the park and general vegetation implantation system are poorly organized from the viewpoint of execution and maintenance which result in fatal failures. It is true that during the spring and fall planting operations the city residents cooperated with the municipal authorities. Thus, in 1959 the Moscow public donated 1,300,000 man-days for planting vegetation in the city; in 1960 - 2,000,000 man-days, in 1961 - 3,100,000, and in 1962 - 3,700,000. But the same city residents failed to cooperate in the care and protection of the implantations. In Swerdiovsk, for instance, a "green patrol" numbering over 30,000, mostly children, was organized for the protection of green areas. Individual trees were assigned to individual persons for their care and protection. The participation of school children in such activity is regarded as a must; but educational work to imbue the children with a love of nature has not reached the desired strength. A proper attitude toward the gifts of nature must be developed in children. A similar appreciation of nature and its sociohygienic significance must become a part of the moral fiber of the physical builders of communism.

Before the October 1917 revolution parks and other green areas accessible to the general public within Moscow city limits comprised 833 hectares, or 9.1% of the city's area which then amounted to 9150 hectares. The per capita green area was 5.9 m^2. The city's green area amounts to 18,700 hectares, or 20% of the city's total area or 18.5 m^2 per resident. However, the distribution of trees, shrubs and other vegetation in Moscow is highly uneven: in the center of the city - within the limits of "Sadovoye kol'tso" (Garden Ring) there is only 0.84 m^2 of verdure per person; in the territory lying between "Sadovoye kol'tso" and the belt-line railroad there are 4.56 m^2 per person, and between the limits of the belt-line railroad and the new automotive beltway there are 8 m^2 per person. Green areas are also distributed unevenly among Moscow city districts. For instance, in the Bauman, Kirov, Frunze and Sverdlov city districts there are only 2.5 m^2 of verdure of any kinds per resident, whereas in the Kuibyshev, Pervomayskii, Dzherzhinskii and Kiyevskii districts there are approximately 62 m^2 per resident. It is planned and hoped that by 198- the green area of all kinds will be brought up to 50 m per resident.

Fifty-six tree species are being planted at present in the city, of which birch comprises 10%, linden 23%, poplar - 10%, pine 9% and spruce 1%.

All large parks are located beyond the limits of "Sadovoye Kol'tso", and are situated mainly in the northwest sector of the city: the Pokrovsko-stershnevskii park extends over 140 hectares, the Ostankinskii park over 74 hectares, the Sokol'nichenskii park with an experimental tree farm over 700 hectares, the Izmailovakii park over 1180 hectares. In the south-western part of the city the park areas are concentrated predominantly along the Moska river; the Gor'kii Central Park of Culture and Rest of 105 hectares, Leninskie gory Park of 85 hectares, the Fili-Kuntsevskii park of 97 hectares, the Khoroshevskii Serebryanyi grove of 92 hectares. As a rule, only parks located in the central part are provided with facilities and accommodations. Industrial discharges heavily polluting the atmospheric air and frequent and numerous park visitors seriously damaged trees and other park vegetation, chasing the birds away from the parks. As a result, most vegetation in the parks became heavily diseased and pest infested.

The average area of all forest territory in Greater Moscow is 92 m^2 per resident if areas inaccessible to the public are excluded. Most of the forests are of a mixed type. Smaller limited forests are found in the Ul'yanovskii district of the Moscow oblast; coniferous forests are found in the Balashikhinskii district. Pine predominates among the coniferous species, and birch - among the deciduous species. The forests' conditions vary: along with the healthy forest park areas (Krasnogorskii, Cherkizov-skii), there are weakened ones, especially in industrial vicinity and in spots most frequently visited by the populace. The basis of the city's green expanses consists of large general municipal parks. They are distributed evenly in planned zones between the arterial transportation highways. The general municipal parks extend into the areas of the forest parks which wedge into the city at some sections or are linked with it by boulevards, park roads and minor green strips.

Plans are in progress to eliminate the existing lack of uniformity in the location of general municipal parks by creating new forest areas. City district parks will play an important part in extending the green area of Moscow and their distribution will have to be made more uniform. The existing public municipal parks (Pokrovskoye-Glebovo, part of the Izmailovskii, of the Kuskovskii, etc.) will henceforth be administered by the city districts. The neighborhood parks and squares are the rest and recreation areas most accessible to the residents. Courtyards, schools, sports, hospitals, and industrial plants' green areas and sanitary protective zones were included in the preceding statistical account. According to present plans municipal parks are to be established in towns and settlements of the so-called forest-park protective belt. The parks in Lytkarino, Balashikha, Lyubertsy, and Mytishchi are to be expanded and provided with recreational and sanitary utility facilities. Part of the territories of the forest-park belt, in which vegetation has been planted, is being set aside as bird and animal sanctuaries, as factors of aesthetic and educational value, and as an aid in the struggle against forest and park pests; these, in addition to their aesthetic and educational value, are imperatively needed in the struggle against forest infestation.

Coniferous tree species such as the pine, spruce, fir, etc. are most sensitive to the effect of atmospheric air pollutants, particularly acid gases. Therefore, a study was made of the effect of sulfur dioxide on the coniferous trees in the parks of Moscow and Podmoskov'e. Sulfur dioxide, which is a component of smoke gases, is discharged into the atmosphere of Moscow in varying quantities depending on the type, quantity, quality, and method of fuel combustion. High air concentrations of acid gases are the cause of acute damage generally referred to as "plant burn". Prolonged effect of low SO_2 concentrations causes chronic plant damage by disturbing the normal physiological and biochemical processes of plant growth. The deterioration and destruction of areas implanted with perennial coniferous plants closely parallels the growth and development of urban invasion into forest areas.

The degree of atmospheric air pollution of some districts of large industrial cities, including Moscow, depends not only on the number of plants located there and the intensity of their discharges, but also on the local topography, the plant location, the pattern of prevailing winds, the height of smokestacks, etc.

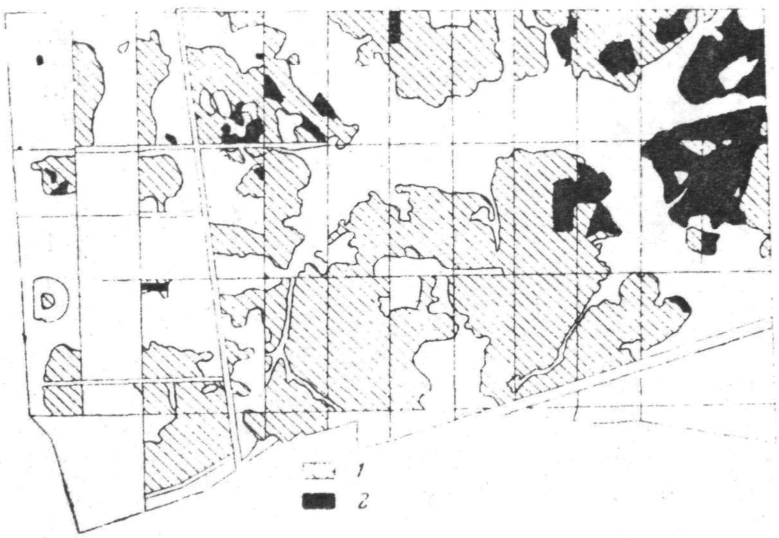
The withering and destruction of Moscow pine was observed in the Sokol'nicheskii and the Izmailovskii parks, in the Pokrovsko-Streshnevo forest, the experimental forest farm of the K. A. Timiryazev Agricultural Academy, and in other similar places. A study of the harmful effect of acid gases on the coniferous species of the Izmailovskii park was conducted in 1959 by the Department of Atmospheric Air Hygiene of the Moscow Sanitary-Epidemiological Station in cooperation with the 5th aerial photography expedition of the All-Union "Lesproyekt" Association. The Izmailovskii park located in the eastern part of the Pervomaiskii district of Moscow, extended in 1958 over 1180 hectares, of which 709 hectares were covered by forest. The rich natural resources of the Izmailovskii park serve as a basis for its varied and highly valuable and rare vegetation species. Up to the early 1930's the upper grade of the park inforestation consisted of the highest quality as well as of oldest (108 years) pine trees. The second grade consisted of broad-leaf tree species, predominantly of 50-70-years old linden and oak, Norway maple, elm and, occasionally, birch. The underbrush consisted of nut tree thickets, viburnum, elder, honeysuckle, etc. No growth weakening or withering of the tree species was observed on the territory of the park. The plant vitality was high .

In the early 1930's the city began to encroach on the park territory from the southwest, i. e., from the direction of prevailing winds. Dwellings and industrial establishments came closer and closer to the park in adjacent districts, poluting the atmospheric air surrounding the park territory with acid flue and smoke gases. At this time the pine species in the western part of the park began to wither. Before long industrial establishments began to appear in the Pervomaiskii and adjoining city districts; electric heat and power plants and their 126 m high smokestacks rose up here and there, followed by clusters of industrial plants; automobile traffic and its exhaust became heavy and intense. At this time withering of the park and forest pine species began to increase encompassing larger areas, spreading northeast from the southewest territory following the direction of the prevailing winds. As a result, only isolated spots in a few blocks of the northeast part of the park have pine growth. Figure 20 shows the reduction in the number of pine trees.

External signs of pine tree destruction are dry tree tops, poor tree crown, loss of normal coloration, early dropping of the pine needles, a large number of undergrown pine cones, shorter and thinner pine trees, etc.

Table 7 shows the reduction in the height increments of pine trees by decades since 1870, recorded in 1959 in one sector of the park. Data in Table 7 show clearly the sharp difference in the rate of pine tree development in height prior to and after 1930. The same is true of the pine development in thickness and with regard to the fruit-bearing, etc. It has been noticed in this connection that SO_2 generally impeded the growth of trees and their fruit bearing capacity. Under the effect of SO_2 pine trees withered, dried up and perished. This is particularly true of first grade older pine timber. Sulfur dioxide also profoundly damaged spruce and fir, i. e. tree species with perennial coniferous needles. Damaged pine groves of all ages have been seen in the territory of the Izmailovskii park, in spite of the multistage structure of the forest areas.

Fig. 20



PLAN OF IZMAILOVSK PARK SHOWING THE COURSE AND NATURE OF CHANGES IN PINE TREE PLANTED AREAS
1 - AREA COVERED WITH PINE TREES IN 1946; 2 - DITTO IN 1959

Table 7

RISE IN THE NUMBER OF PINE TREES

TREES' AGE IN YEARS	METERS OF HEIGHT INCREASE PER DECADES	
	1870 - 1929.	1930 - 1959.
112	3,8	0,4
85	4,6	0,6
79	4,6	1,3

An investigation of the park territory groves made in 1959 failed to disclose any considerable infestation with harmful pests or diseases. At present pine trees are being replaced in the upper geologic strata by deciduous species, predominantly by the linden. Generally, deciduous species are more gas resistant than coniferous species. The rapid course of pine groves replacement by deciduous species for the past 27 years is well presented by the forest-management data for 1931 and 1958 listed in Table 8.

Table 8

TREE GROVE AREAS IN HECTARES ACCORDING TO SPECIES

SPECIES	1931		1958	
	AREA IN HA.	%	AREA IN HA.	%
PINE	580	77,4	74	10,4
SPRUCE	45	6,0	1	0,1
FIR	7	0,9	—	—
LARCH	4	0,4	22	3,1
OAK	—	—	89	12,5
LINDEN	22	2,0	288	40,9
BIRCH	60	8,0	154	21,7
ASPEN	21	2,8	29	4,0
OTHER	12	2,5	52	7,3

Thus, in the past 27 years the areas of the park's pine groves were reduced from 580 hectares to 74, spruce and fir have completely disappeared. Along with this, a sharp increase was noted in the area of linden, birch and oak groves, and of other deciduous species. According to the 1948 forest-management data, the average age of surviving pines has dropped to 90 years. The basic background of the park is composed at present of linden groves averaging 74 years. The linden tree is not highly smoke resistant. According to 1958 evaluation data, the linden of the basic park forest areas was showing signs of widespread weakening, and in a large part of the territory can be described as of second-class vitality. Up to recent years the polluted atmospheric air had affected mainly the tops of the pine tree crowns. After the pine trees perished the toxic air pollutants began to affect the peripheral parts of the linden grove, tree crowns becoming the primary cause of stunting the growth and development in the park vegetation.

The effect of atmospheric air pollution on pine grove trees was studied with special reference to local tree sprouting conditions, economic tree quality, value of the groves, and the composition of the smoke pollution in the vicinity of the experimental forest farm of the K. A. Timiryazev Agricultural Academy; the latter study extended over several years. The forest farm has an area of 248.7 hectares. Pine trees with an average age of 76 years prevailed in the groves of the experimental farm. Here, as in the Izmailovskii park, the city spread close to the southwest territory of the farm in the 1930's; simultaneously with this the pine species began to wither rapidly on a large scale; at the same time broad lead trees remained practically unaffected. There were no large industrial establishments close to the boundary of the farm. The air pollution came primarily from the railroad, residential boiler rooms, and automobile exhaust. The outward signs of poisoning were the same as in the case of the Izmailovskii park pine groves. But here the pine died out not over the entire forest farm territory but in a comparatively broad strip along its southwest edge, and in narrow strips along the asphalt paved highways. The pine in the center of the farm and along its northern edge survived either as the sole species or mixed with deciduous species. Table 9 presents data of a study of Izmailov park atmospheric air conducted in 1955 - 1961. The data point to the prevailance of year-round air pollution with sulfur dioxide.

Table 9

ATMOSPHERIC AIR POLLUTION WITH SULFUR DIOXIDE OVER IZMAILOVSK PARK

MONTH	MAXIMAL SINGLE CONCENTRATION IN MG/M³				
	1955	1956	1957	1958	1959
APRIL	1,25	1,20	1,58	2,15	0,9
MAY	0,09	1,62	1,60	0,80	0,34
JUNE	0,70	1,64	0,90	0,54	0,35
JULY	0,73	1,91	0,73	0,63	0,29
AUGUST	1,47	0,84	0,89	0,86	0,18

Reduction in sulfur dioxide concentration over the years is explained by the fact that at the city's electrical heat and power plants and at the industrial plants, including Central Electrical Power Plant-11, the previously burned Podmoskov'e coal was at first replaced by low-sulfur containing Donets coal; later the combustion chambers were converted to burning gas, which significantly reduced the quantity of discharged sulfur dioxide. In 1952 the discharges of sulfur dioxide by Central Plant-11 amounted to 72,000 t, and in 1959 to only 25,000 t.

Concentrations cited in Table 9 pertain to the vegetative period. However, during the winter, fall and early spring months, when the greatest amount of fuel was burned in the residence boiler rooms, sulfur dioxide concentrations in the atmospheric air exceeded the indicated two-and three-fold. Such high sulfur dioxide concentrations cause permanent blight, "burn" damage to coniferous needles of the pine species. The present hygienic maximum permissible single concentration of sulfur dioxide is set at 0.5 mg/m^3. No one has as yet proposed an acceptalbe maximal sulfur dioxide concentration in the atmospheric air with regard to plants. Spruce withstands 0.09 - 0.2 mg/m^3 of SO_2 without showing unfavorable effects. The number of air samples exceeding the single maximum permissible sulfur dioxide concentration of 0.5 mg/m^3 (which is considerably higher than that endured by spruce) was 27.1% of all air samples taken that year; in 1956 the percent of such samples was 28.2, in 1957 - 29.2, in 1958 - 18.7, in 1959 - 6, in 1960 4.5, and in 1962 - 3.8.

The sulfur dioxide concentrations in the atmospheric air in the K.A. Timiryazev Agricultural Academy forest farm territory differed sharply from those indicated above. According to observations made in the spring and summer months of 1955, the sulfur dioxide concentrations in the air surrounding the greater part of its territory ranged between 0.07 and 0.19 mg/m^3; only in the sections of the territory's southwest edge, in the proximity of the railroad line and residential houses did the sulfur dioxide rise from 0.23 to 0.36 mg/m^3. Nowhere in the forest farm territory did the sulfur dioxide concentration stay within the MAC of 0.5 mg/m^3. Maximum single concentrations did not exceed 0.4 mg/m^3.

Thus, the sulfur dioxide concentration in the air over the Izmailovskii park territory differed considerably from its concentration over the forest farm. This was clearly reflected in the degree of toxic effect and damage to the arboreal vegetation of these two grove areas. It can be concluded on the basis of the above that for the preservation and restoration of Moscow urban and suburban forest areas the sulfur dioxide concentration in the surrounding atmospheric air must not exceed 0.10 - 0.20 mg/m^3. Deleterious effect of gases on the Izmailovskii park coniferous groves has now been clearly demonstrated. All other conditions, such as the state of the underground water, excessive attendance by visitors, breaking up of the soil top, poor care, etc., being equal the leafy tree varieties survived and proliferated well and extended the area of their growth 5.5 - 13 - fold where the coniferous evergreen species gradually perished.

Similar studies were conducted in the forests and parks of Podmoskov'e (Lower Moscow). In 1961-1962 a study was conducted jointly by the Department of Atmospheric Air Hygiene of the Moscow Sanitary-Epidemiological Station and the Siviculture Laboratory. Candidate of Biological sciences A. P. Shcherbakov studied the state of tree groves in the Moscow forest park belt under existing air pollution conditions. The purpose was to determine experimentally the harmful effect of gaseous smoke discharges coming from the city's industrial establishments on forests and other zones of green areas. The direction of prevailing winds in Podmoskov'e is from west eastwardly and from southwest to northeast. Therefore, forests and parks located in the eastern part of Moscow's forest-park protective belt were selected for study: the Podmoskovskii, Mytishchinskii, Balashikhinskii forest and parks, and the Kuchinsk forest industry. Forest areas in the western part of the green belt, in the Zvenigorod district, which included Khlyupinsk, Sharapovsk, Stepanovsk, Nikolina gora mountain, were used as controls.

Three plots of approximately 0.5 hectare were selected in each forest and forest park. The selected plots were covered by the same type of 15-20 and 60-80 year old coniferous tree species and by the same type of herbage; the experimental work was conducted on these plots. Results of laboratory investigations showed that the air over the eastern and northeastern sectors of the green zone, in the Podmoskov'e, Mytishchinsk, Balashikhinsk forest parks and in the Kuchinsk forest areas contained detectable concentrations of sulfur dioxide, nitrogen oxides, chlorine and chlorides through the year. In the western part of the city, in the smokeless districts, these pollutants were not detected in the air, or were found in negligible concentrations. Table 10 shows the maximum concentrations of sulfur dioxide and nitrogen oxides detected in the atmospheric air in the eastern and western forests and parks.

Table 10

ATMOSPHERIC AIR POLLUTION IN MOSCOW TREE-GROVE PARKS IN 1962
MAXIMAL CONCENTRATIONS IN MG/M^3

RESPONSIBLE AUTHORITY	SULFUR DIOXIDE	OXIDES OF NITROGEN
SMOKY REGIONS		
BALASHIKHINSK LESPARK-HOZ. .	0,3	0,7
LOWER MOSCOW " . .	1,1	1,87
MYTISHCHINSK " . .	0,3	0,48
KUCHINSK FORESTRY	0,9	0,27
SMOKE-FREE REGIONS		
KHLYUPINSK FORESTRY	н/о	0,7
SHARAPOVSK FORESTRY	н/о	н/о
NIKOLINA HILL	н/о	0,12

High concentrations of oxides of nitrogen, but no SO_2 were found in the atmospheric air over Khlyupinsk forest area and Nikolina mountain. This may have been due to the fact that the air samples were taken at the edges of the forest, close to the sides of a highway which had heavy automotive traffic. No oxides of nitrogen were found in the Sharapovsk forestry area where the air samples were collected at some distance from the highway. More significant data were obtained in studying the pollution intensity of rain precipitation by industrial gaseous discharges and soluble nitrogenous substances in the eastern districts as compared with the unpolluted districts. The highest intensity of soluble and insoluble aerosols was detected in the precipitation falling close to Moscow in the Podmoskov'e forest park. Such intensity became gradually less in the Kuchinsk and Balashikhinsk districts, and in the Mytishchinsk forest park; lowest precipitation pollution intensity was noted in the Zvenigorod district. Assigning to the intensity of pollution aerosols in the atmospheric precipitation of the Zvenigorod district the value of 100, then the corresponding value in the Podmoskovsk forest park would be 1126 for the insoluble and 271 for the soluble aerosols; in the Balashikhinsk and Kuchinsk forest parks the respective values were 495 and 253, and in Mytishchinsk Park 239 and 180. The sulfate and chloride precipitation components of smoke-polluted districts were 3 to 4 times as high as similar precipitation components of the smoke-free park areas. Thus, the precipitation permeating into the soil increased its acidity and, as a consequence, unfavorably affected the growth of the tree species, as shown dy data listed in Table 11.

Table 11

ATMOSPHERIC AIR POLLUTION IN SMOKY REGIONS OF MOSCOW'S "GREEN ZONE". (AVERAGE INDEXES IN MG PER CUBIC METER PER DAY BEGINNING DECEMBER 1961 THROUGH OCTOBER 1962

FOREST AUTHORITY	INSOL. AEROSOLS	ASH	SULFATES	CHLORIDES
LOWER MOSCOW LESPARK-KHOZ	428	287	217	13
KUCHINSK FORESTRY	188	108	181	9
MYTISHCHINSL LESPARK-KHOZ.	91	56	135	5,5
NIKOLINA HILL	38	16	57	4,8

The above described air and precipitation factors and pollutant components similarly affected the eastern part of the forest park area with respect to damage caused to coniferous groves.

An inspection made by forestry specialists yielded the following results: conditions of trees were classed as "sick", "completely dry", and "unaffected". The percentage ratios of such trees in different forests are shown in Table 12.

Table 12

CONDITION OF STANDING TIMBER IN AREAS IN 1962 (IN PERCENT)

FOREST AUTHORITY	CONDITION OF STANDING TIMBER		
	DRY	DISEASED	HEALTHY
SMOKY REGIONS			
BALASHIKHINSKII LESPARK-KHOZ .		83	17
LOWER MOSCOW " . . .	—	100	—
MYTISHCHINSKII " . . .	1,0	84	15
KUCHINSK FORESTRY	4,0	55	41
SMOKE-FREE REGIONS			
KHLYUPINSK FORESTRY	—	4,0	96
STEPANOVSK FORESTRY	1,0	3,0	96
SHARAPOVSK FORESTRY	1,0	2,0	97
NIKOLINA HILL	—	—	100

The same is also noted with regard to rate of growth noted in pine and spruce groves, as shown by records accumulated for the period of 1956 - 1961 and listed in Table 13.

Table 13

GAIN IN THE GROWTH OF PINE AND SPRUCE PLANTATIONS IN CENTIMETERS PER YEAR

FOREST AUTHORITY	1956	1957	1958	1959	1960	1961
BALASHIKHINSK LESPARK-KHOZ (SPRUCE - 80 YEARS)	3,2	4,0	3,6	3,0	3,5	3,4
MYTISHCHINSKII LESPARK-KHOZ (SPRUCE - 73 YEARS)	4,5	5,0	4,6	3,0	2,4	9,6
SHARAPOVSK FORESTRY (SPRUCE - 73 YEARS)	—	19,0	16,6	25,0	20,8	19,8
STEPANOVSK FORESTRY (SPRUCE - 73 YEARS)	25,0	18,0	20,7	17,0	16,0	27,0

Results of S and N determinations in pine and spruce needles, conducted by A. P. Scherbakov and of microbiological studies of the soil in smoke-polluted and control districts in Podmoskov'e, indicated that a connection existed between the intensity of the atmospheric air pollution and the quantitative determination results. For example, needles of pine and spruce growing in smoke-polluted forest park areas contained a higher percent of sulfur on the basis of dry substance, and less nitrogen, in milligrams per 100 coniferous needles as compared with the controls. The contents of nitrogen and of microorganisms were correspondingly less in the soil of smoke-polluted sectors than in the control sectors. This circumstance was clearly-reflected in the nutritional condition and general development of the trees, as shown by data in Table 14.

Table 14

SULFUR AND NITROGEN CONTENT IN CONIFEROUS PINE AND SPRUCE NEEDLES AND IN SOIL MICRO-ORGANISMS (AVERAGE DATA)

FOREST AUTHORITY	% OF S ON DRY WT, BASIS	MG OF N PER 100 NEEDLES	THOUSANDS OF MICRO-ORGANISMS PER 1 G OF DRY SOIL	REGION
SPRUCE - 80 YEARS				
KUCHINSK FORESTRY	0,19	5,2	637	SMOKY
SHARAPOVSK FORESTRY	0,12	5,7	2 002	SMOKE-FREE
MYTISHINSK LESPARK-KHOZ	0,20	5,5	—	SMOKY
STEPANOVSK FORESTRY	0,14	7,1	—	SMOKE-FREE
PINE - 80 YEARS				
LOWER MOSCOW LESPARK-KHOZ	0,20	11	1 209	SMOKY
KHLOPINSK FORESTRY ...	0,1	22	1 835	SMOKE-FREE
BALASHIKHINSK LESPARK-KHOZ	1,17	13,9	—	SMOKY
NIKOLINA HILL	0,12	29,5		SMOKE-FREE

Gaseous atmospheric air pollutants damaged coniferous trees most in the fall and winter months because pollution of the atmospheric air with sulfur dioxide was most intense during the heating seasons; in addition, sulfur dioxide being heavier than air did not rise to the upper strata of the atmosphere, but spread along the ground. Meteorological conditions can enhance the harmful effect of gaseous air pollutants upon plants. Incomplete combustion products form condensation nuclei with droplets of fog or dew in air layers lying close to the surface of the soil during the winter season. The different components of air-pollution complexes (carbon monoxide, carbon dioxide, sulfur dioxide, tars, etc.) are less aggressive individually than as a complex. These substances tend to become concentrated into a fog as the results of additive effect and become more aggressive to plants. The wind direction and force frequently enhanced the effect of polluted air on plants.

In considering the toxic effect of smoke and gas air complexes upon vegetation account should be taken of the fact that tree groves impeded the penetration of windblown polluted air. B. F. Dokuchayeva et al recommended that protective land strips be implanted with trees as shields for the protection of forest groves consisting of more valuable tree species against smoke and harmful fumes, and to eliminate the unfavorable physiological effect of mechanical and chemical action. The effect is a double one: a) upon the metabolic apparatus of the leaves directly as a result of sulfur dioxide absorption through the leaf stomata distributing the CO_2 assimilation process thereby lowering photosynthesis, and b) inactivating the chloroplasts' iron, disturbing the respiratory quotient which becomes greater than unity, breaking down vitamin B, creating an unfavorable protein and carbohydrate balance, and causing an excessive accumulation of silicic acid and strontium in the leaves. The above effects are most pronounced in coniferous needles and buds in the smoke-polluted districts of the Moscow forest-park belt. Young and old trees without exception lost much moisture, absolute dry weight, and height. The synthesizing leaf function is disturbed so that the process of growth becomes abnormal and impeded. The ratio between the number of needles and length of shoots becomes reversed, as shown by the fact that in smoke-polluted districts the number of needles per 1 cm of shoot was generally much greater than in trees growing under pure air conditions. Needles of peripheral shoots assumed a broom-shaped distribution, grew closer together and were considerably shortened.

Gaseous air pollutants reduced the number of healthy trees to one sixth, while the number of withered and withering trees was 85 times as great as in trees growing in clean air areas. In addition, the annual rate of height increase over the past 5 years fell by 13 to 73%. Simultaneously with the weakening and withering of the trees, the number of trunk pest species and their general population rose sharply.

Harmful smoke and gas pollutants unfavorably affected trees and other vegetation growth indirectly through the soil. The natural buffering capacity of the soil becomes overpowered, so to speak, by the precipitation-introduced air pollutants and the basic soil pH becomes disturbed, the soil's bases become depleted, the normal balance of microbial life circles becomes destroyed, soluble aluminum and strontium salts accumulate in the soil, causing the normal regime of plant nutrition to break down. Ultimately almost all smoke particles, soot, dust, and gases which pollute the air find their way into the soil. Some components, such as silicon, fluorine, lead, copper, zinc, chrome, strontium, etc., entered the soil as trace elements which are essential components of the food ration in trace quantities, but have toxic effects in larger doses. Heavy metals penetrated into the soil to a depth of 25 cm. Experience showed that the soil absorbed great quantities of these substances. The unfavorable effect of chemical admixtures and mechanical elements in the air is more pronounced in forest soils than in soil used for agricultural cultivation even though forest soil has a higher buffering action and greater humus content. Agricultural soil is plowed over repeatedly and fertilized each year. This helps to overcome the harmful effect of smoke gases on them.

Different tree and shrub species manifest different biological resistance against harmful chemical and mechanical air polluting factors. The larch proved to be the most resistant coniferous of trees which change their needles annually; next comes the pine, the needles of which are replaced every 2-3 years; it is followed by the fir, the needles of which are renewed every 3-5 years; then comes the spruce which changes its needles every 7 years.

Some investigators divide tree species into three groups, with respect to the degree of their resistance to smoke and flue gases: highly resistant, slightly sensitive, and highly sensitive. They base their classification on the following criteria: premature falling of leaves or needles, the appearance of spots on the leaves, loss of leaves on tree tops, lowering of the tree's resistance to harmful insects, and a fall in the rate of vertical and thickness growth. These criteria have been used by the present authors in determining the degree of harmful effect of smoke and flue gases on the growth of spruce and pine in the eastern districts of the Moscow forest park belt.

Diagnostic techniques are being developed at present based on external criteria or on laboratory analysis of wax and SO_2 leaf content for the determination of harmful air pollutant effects on trees. Successful use is also being made of biological indicators: gladiolus for detecting fluorine, pine which is capable of accumulating sulfates without showing signs of damage; meadow grass, sensitive to general gas pollution of air; the sunflower, the cherry sensitive to the presence of sulfur oxides in the air . Mention should also be made of possible means for increasing tree hardiness in the eastern part of the Moscow park belt. The possibility of using mineral fertilizers for such purposes has been mentioned extensively in the literature. It has been suggested that systematic application of mineral and nitrogenous fertilizers to the soil in districts subject to the effect of acid gases and smoke, supplemented by lime and Ca-Mg soil treatment may improve the soil structure to a considerable degree. The fall application every 3 - 5 years of 2 or 3 t of lime, dolomite, or marl per hectare of forest area can be recommended as an expedient, effective, and economical measure for the rational maintenance of forest-park agriculture. The application every second spring of 100 kg of ammonium nitrate per hectare of forest and park area, raking same into the soil, is also recommended. Young trees should be sprayed with a 0.5% solution of urea; this will markedly enhance their growth.

Results of experimental studies and of observations described above clearly established that smoke polluted atmospheric air destroyed coniferous tree species. The results also indicated that the 0.5 mg/m^3 MAC of SO_2 adapted as the general hygienic standard for man should be lowered to 0.10 - 0.20 mg/m^3 for trees, especially of the coniferous species. The damaging effect of atmospheric sulfur dioxide upon vegetation must be reduced, if not completely obviated. This can be accomplished by moving the electric power generating station beyond the city limits taking into consideration direction of prevailing winds and by introducing agro- (and soil) technical and chemical pollution neutralizing soil treatment. Future inforestation of suburban zones subject to effects of industrial discharges, particularly those containing sulfur dioxide, should be done with trees of 4-5 needle and leaf bearing smoke-resistant species of different ages. Such arborization zones should be belted around by forest protection areas implanted by gas-resistant species. The sanitary-epidemiological station of Moscow is engaged in developing standard procedures for the protection of inforestations, tree groves, and other cultivated vegetation areas. The general plan is as follows:

a) arrive at a single standard set of MAC for atmospheric air pollutants non-toxic to plants;

b) establish a rational and reliable classification of smoke- and gas- resistant trees and flowers and other cultivated and non-cultivated vegetation used in developing green areas exposed to the effects of different chemical substances found in polluted atmospheric air;

c) prepare a list of rational agrotechnical prophylactic measures for the prevention of coniferous trees withering in municipal and forest parks, and for enhancing the stability, vitality, and economic value of the inforestated trees; to develop measures for the attraction of birds to nest in the forest parks and groves.

Such measure should become standard in the practical work of architects, forest planners, foresters, and other workers engaged in the planning, development, and exploitation of arboreal implanations. The Moscow sanitary-epidemiological station submitted such a proposal to the Central Council of the All-Union Society for the Protection of Nature and the Development of Vegetation implantation areas.

BASIC TRENDS AND PROSPECTS FOR IMPROVING AIR CLEANLINESS

A system of measures for the abatement and control of Moscow atmospheric air pollution was developed and adapted cooperatively by pertinent central governmental and municipal organizations. Some of the measures constitute a part of the technical and economic basis of the plan for future development of Moscow. Recommendations made by the present authors can be reduced to the following:

1. Plants of chemical, woodworking, and construction material industries are the principal sources of atmospheric air pollution. To diminish the harmful effect of their discharges, only those plants should be permitted to operate in the city which serve the immediate everyday needs of the populace.

2. Metallurgical plants greatly pollute the city air with many toxic substances. Since the raw products on which the plants' production depends must be imported into the city, the plants should be moved to points nearest to the sources of such raw products.

3. Foundries of machine-building plants discharge into the atmospheric air large quantities of dust, of metallic oxides, of carbon monoxide, and other harmful substances. Exhaust-gas discharges of cupola furnaces cannot be purified. Therefore, casting shops should be separated from the machine-building plants, and a single central casting plant be organized beyond the city limits.

4. Crushing and grinding departments at asphalt-concrete plants heavily pollute atmospheric air with dust due to organized and unorganized dust discharges. The obsolete plants should be replaced by 5 - 6 new plants equipped with up-to-date air purifying installations.

5. It is not practical, and in fact impossible, to surround all city industrial plants by sanitary protection zones 500 m or more wide; they

should be moved from the city or they should reorganize on a more modern sanitary basis.

6. Compliance with the last part of recommendation 5 will make possible to reduce the specified width of sanitary protection zones.

7. Maintenance of sanitary protection zones surrounding all industrial production plants presuppose the removal of all the populace, children's and medical facilities, physical-culture building and other similar facilities from the territory of such zones, followed by their complete implantation with trees and shrubs.

8. The construction in the city of new electric heat and electric power stations which will use gas as fuel, will saturate the air with water vapor, which may lead to changes in local meteorological conditions by reducing hours of sunshine and increasing the number of foggy and rainy days. In addition, the use of coal and mazut as reserve fuel will pollute the atmospheric air to a considerable extent with products of incomplete fuel combustion; therefore, new heat and electric power stations should be built beyond the city limits and surrounded by sanitary protection zones of adequate width.

9. In order to restrict the consumption of gas and solid fuel the general utility, community, and industrial combustion chambers must be converted to operation by electric heat as a means of eliminating or reducing the use of gas and hard fuel.

10. It is imperative that low-sulfur mazuts be developed for use as reserve fuel as a means of preventing air pollution with sulfur dioxide and fly ash.

11. Atmospheric air pollution with motor-vehicle exhaust fumes, must be reduced or eliminated by replacing gas automotive transportation by electrical traction facilities, developing improved internal combustion engines, installing exhaust-gas afterburners, supplying the city with high-grade gasoline, and employing liquid gas as a fuel.

12. Organize high-speed nonstop motor vehicle routes as a means of reducing the discharge of toxic substances from motor vehicle exhausts; in this connection it is recommended that crosswalks and vehicular cross-overs should be built at different levels wherever possible.

13. Methods should be developed in the immediate future for the recovery of organic and aromatic compounds and of open-hearth furnace discharges and for the recovery of small quantities of solvents.

14. A special plant for designing and building purification installations and an expert organization for planning, installing, and monitoring all types of purification installations must be created to serve the needs of Moscow industrial plants.

It is essential, if not mandatory, that vegetation implantation areas be evenly distributed with the planting of verdure throughout Moscow, including forest parks, groves, squares, sanitary protection zones, and areas next to street sidewalks, etc. The following per capita standards of green areas must be the goal: 50 m^2 within the city limits, and 130 m^2 within the forest-park belt.

Railroad transportation should be electrified as extensively as possible, and all auxiliary railroad facilities, such as repair shops, storehouses and the like, should be moved beyond the city limits.

APPENDIX

1 - Limits of allowable concentrations of harmful substances in the atmospheric air of inhabited locations

2 - Substance No. : 3 - Name of Pollutant 4 - Maximal allowable conc'n. 5 - Max. single conc'n. 6 - Average daily

1	Acroleine
2	Amyl acetate
3	Amylene
4	Amyline
5	Acetone
6	Acetophenon
7	Benzene
8	Gasoline (Crude oil, low S content, computed on the basis of C)
9	Butyl acetate
10	Butylene
11	Vinyl acetate
12	Hexamethylenediamine
13	Dichlorëthane
14	Dimethylfomamide
15	Dinyl
16	Isopropylbenzenehydroperoxide
17	Isopropylbenzene
18	Methanol
19	Methylacetate
20	Maleic anhydride
21	Methylmetacrylate
22	Maganese and its compounds
23	As (inorganic compounds, arseneous H excluded) computed on the basis of As
24	Nitrobenzene
25	Carbon monoxide
26	Oxides of nitrogen, as Na_2O_5
27	Propylene
28	Dust, non-toxic
29	Mercury, metallic
30	Sulfur dioxide
31	Hydrogen sulfide
32	Carbon disulfide
33	Sooth
34	Sulfuric acid
35	Lead and its compounds (Tetraethyllead excluded)

36	Lead sulfide
37	Sulfuric acid as its H-ion concentrate
38	Hydrochloric acid as its H-ion concentrate
39	Nitric acid, as its H-ion concentrate
40	Styrol
41	Formaldehyde
42	Toluilienedi-isocyanate
43	Phosphoric anhydride
44	Fluorides
45	Phenol
46	Furfurol
47	Chlorine
48	Chlorobenzene
49	Hydrogen chloride
50	Chloroprene (2-chlorobutadien 1, 3)
51	Chromium, hexavalent, computed as CrO_3
52	Ethylacetate
53	Ethylene
54	Cyclohexanol
55	Cyclohexanon

Notes - 1. When the atmospheric air contains simultaneously several air pollutants the toxic or harmful effects of which are of an additive (or summation) character, then the final or limiting concentration should be determined by the following formula:

$$X = (A/M_1) + (B/M_2) + (C/M_3) \quad \text{where } A/M_1,\ B/M_2,\ C/M_3$$

are the desired concentrations of the pollution components arrived at by dividing A, B, and C, the components' concentrations present in the air, correspondingly by M_1, M_2, and M_3, their corresponding maximal allowable concentrations.

The following substances belong to groups the harmful or toxic properties of which are of an additive or summation nature: 1) sulfur dioxide and sulfuric acid aerosol; 2) hydrogen sulfide, and dinyl; 3) isopropylbenzene and peroxide of isopropylbenzene; 4) ethylene, propylene, butylene, and amylene; 5) strong sulfuric, hydrochloric, nitric, and other mineral acids.

2. If the atmospheric air contained simultaneously hydrogen sulfide and carbon bisulfide the sanitarian should be guided by the individual unmodified officially adopted maximal concentrations for each individual substance.