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CHAPTER I [of the book 'Aerologiya']

INTRODUCTION TO AEROLOGY

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1. The Subject and Problems of Aerology

Aerology refers to that science devoted to research on physical phenomena and processes occurring in the free atmosphere, i.e., above the surface air layer which is directly influenced by the earth's surface. Comparatively recently aerology came to be considered an independent discipline of meteorology -- the science devoted to the study of physical phenomena and processes occurring in the whole atmosphere. Since the atmosphere is the general subject of study of the various divisions of meteorology, all meteorological disciplines are closely interrelated and together utilize the results and conclusions obtained. Aerology is directly allied to synoptical and dynamic meteorology.

In relation to studying aerological problems in the field of free atmosphere physics, it is natural that the development of aerological methods and instruments should be considered.

The study of the free atmosphere is effected by the use of special instruments which are sent aloft in flying apparatuses. For the study of higher atmospheric layers, various physical methods are widely used: optical, radiophysical and others. The result of aerological observations permit us to clarify the peculiarities of processes occurring in the atmosphere, to obtain physical ex-

planations for them, and to determine the laws of their development.

The results of aerological studies are widely applied, primarily in the weather service. The analysis and forecasting of weather cannot be fully grounded nor successful without the utilization of aerological data.

The development of aerological observations in the USSR is an important condition in the success of Soviet synoptical meteorology.

The value of aerology to the weather service determines its role in satisfying the demands made by various branches of national economy, transportation, and others. The results of aerological observations are especially widely applied in aviation. The distribution of winds and temperatures with altitude, the height and concentration of cloud layers, probability of aircraft icing -- all of this has a great bearing on the successful completion of flights.

The series of problems which aerology places before itself is quite important in the general complexity of meteorological studies. The following must be included therein: study of clouds (height and thickness of clouds, their micro-structure), icing, study of the stratosphere, atmospheric fronts, processes of turbulence and so forth. As a result of aerological studies, a scheme of the atmospheric structure is provided, many processes occuring

therein are discovered, the structure of the fields of meteorological elements is clarified, and a basis for certain atmospheric phenomena is provided.

From this we may see how great is the role of aerological observations and how practical its application. Therefore it is understandable that under the conditions in our country, with its planned socialist economy, great attention is devoted to the study of the atmosphere.

The more widely applied systematic aerological observations have the aim of determining the more important physical characteristics of the free atmosphere at various geographical points. The basic meteorological elements are included primarily in these characteristics: wind, pressure, temperature and humidity of the air. Their measurements in the free atmosphere is considerably more difficult than observations at the earth's surface. Aerology fully utilizes the latest achievements in physics, radio technology, instrument construction, aviation, and so forth.

The course offered here is devoted to the explanation of contemporary methods in aerological observations.

2. A Brief Review of Methods of Aerological Observations

Methods of aerological observations are differentiated according to the object studied and the means applied thereto. As we have stated, systematic aerological observations, in the main, provide

information on the velocity and direction of the wind at various altitudes, distribution of pressure, temperature, humidity, and the height of clouds. At the same time, aerological methods are utilized also for the study of the composition of the air, distribution of radiant energy, electrical condition, intensity of cosmic radiation, and so forth.

Methods of aerological research may be divided into two groups according to the character of means applied: methods of direct aerological observations and the so-called indirect methods.

In the first case, instruments sent aloft with the aid of flying apparatus, either lighter or heavier than air, serve for studying the physical conditions of the free atmosphere and its changes.

Indirect methods give the opportunity for studying the atmosphere by observing the distribution of sound waves (acoustical method), of optical phenomena (searchlight beam, brightness of the twilight sky, lightness of the night sky, meteors, northern lights), and the distribution of radio waves (reflecting of radio waves, atmospherics and others). These methods do not require flying craft.

The methods of the first group, used daily in the aerological station network, are the basic and more widely applied for the study of the free atmosphere up to altitudes of 20 to 30 kilometers. Direct aerological observations are usually conducted with the aid

of instruments (meteorographs), automatically recording changes in meteorological elements during the ascent of free and captive aerostats, weather balloons, aircraft and aerial kites. An observer participates during aerostatic and aircraft flights in order to conduct observations and make measurements. Together with this, there are methods of observation in which the results of the measurements of ascending instruments are recorded by an observer or a special apparatus located on the ground. Such are: (1) the method of pilot balloons in which the location of the balloon during flight is determined with the aid of a theodolite, and the method of radio pilots in which the observations of the balloon are made with the aid of radio locators or radio direction finders; (2) the method of radio meteorographs in which the results of meteorologic measurements are transmitted by radio and are recorded by special radio receiving equipment on the ground.

In everyday aerological observation practice, these latter methods, namely, with recording of results on the ground, have the widest application.

At the present time, study of air currents in the free atmosphere is conducted mainly by methods of the pilot and radio balloon observations. For the measurement of pressure, temperature, and humidity at various altitudes, radio meteorographs carried on hydrogen-filled balloons, as well as meteorographs on aircraft are used.

The study of dimensions of cloud strata is made by the pilot balloon method, as well as with the aid of nephographs and radio meteorographs on aerostats and airplanes.

Study of the micro-structures of clouds, developing more and more in the last several years, requires especially equipped flying laboratories; in this work, the methods of radio location have also been applied.

Before arriving at the present contemporary condition, the methods of aerological research went through a not inconsiderable historical development related to the development of meteorology, as well as to the general development of science and technology.

3. Appearance of Aerological Research. Organization of Systematic Aerological Observations in Russia in the Nineteenth and Early Twentieth Centuries

The problems involved in studying the upper atmospheric layers first caught the attention of scientists in the middle of the eighteenth century. The founder of Russian science, M. V. Lomonosov, was the first to point to the importance of this type of study. His ideas of 200 years ago indicated the value of studying the atmosphere.

Studying the atmospheric conditions from various levels in mountains, a method making an appearance at that time, could not characterize the actual conditions of the free atmosphere. Such

a problem could only be solved by flying apparatus. On 4 February 1754, at a conference of the Academy of Sciences, M. V. Lomonosov came forth with the announcement regarding his work on a machine designed to carry various meteorological instruments into the upper layers of the atmosphere. This "aerodynamic machine" with two propellers, revolving in opposite directions, had the appearance of a model helicopter. (Helicopter -- a flying machine ascending by means of an aerial screw co-located on a vertical axis.) However, M. V. Lomonosov did not succeed in applying his invention.

The beginning of the study of the free atmosphere is closely tied with the appearance of air navigation.

To our native land belongs the construction of the first aerostat and the first flight in it. In a manuscript among reports of first flights made in Russia, there is the following description of a balloon flight made in 1731: [written in old Russian] "Kryakutnoy, the scribe's assistant from Nerekhta, made the furvin (a bag) like a large ball, filled it with smoke, unclean and stinking, made a loop, sat in it and" ..." ascended "higher than a birch tree." In this manner, the French brothers Montgolfier were able to duplicate the experience of Kryakutnoy only 52 years later (in 1783).

The invention of the aerostat permitted the beginning of the study of the free atmosphere, but in the first flights observations were made incidentally, the methods of observation were incomplete, and the results insignificant. The first flight

specifically for scientific research was made in Russia by Academician Ya. D. Zakharov on 30 June 1804. In this flight an extensive observation program was completed: measurement of pressure and temperature and study of the composition of the air; besides that, a study of acoustical, electrical and magnetic phenomena, solar radiation and others was made. The aerostat reached an altitude of some 2,600 meters. A lowering of temperatures from 23.8 degrees at the surface to 5.6 degrees at maximum altitude was established by observations. All observations made presented great scientific value.

After Ya. D. Zakharov's flight, there were some research ascents made in France with the participation of Gay-Lussac and Biot, who discovered the fact, important for the methodology of temperature measurements, of the heating of the thermometer through the action of solar radiation.

It is necessary to note that the problems of aeronautics and their application to scientific investigations began to invite the attention of the leading circles of Russian society quite early. Thus, in 1818, the progressive social worker V. N. Karazin suggested that means be provided for the conduct of experiments with captive balloons for investigating various layers of the atmosphere. Still earlier, in 1806, in the first Russian round-the-world expedition of I. F. Kruzenshtern, small balloons filled with heated air were released for the study of air in the free atmosphere. Such observations later brought about the appearance of the method of pilot balloons. After the above-

mentioned flights of Ya. D. Zakharov and other scientists in investigations aided by aerostats, there was an interval until the 60's of the nineteenth century when flights for scientific purposes were resumed. In this the investigators sought to obtain results in the study of the atmosphere by way of more systematic flights, greater altitudes, and improvements in the methods of measurement.

In Russia, investigations aided by aerostats were conducted beginning in 1868 by M. A. Rykachev (later Academician and Director of the Main Physical Observatory). On one of his flights (1873) to ascertain reliable altitudes for the aerostat, observations by theodolite were made.

Of great importance in the development of study of the free atmosphere was the work of the Russian scientific genius D. I. Mendeleyev. His theories and direct work in the field of meteorology attracted the attention of scientific circles and influenced the development of aerology. Regarding the value of aerological investigations made in 1870, D. I. Mendeleyev wrote: "Our meteorologic conclusions will remain as realistic as judgments of the crab crawling along the bottom of the sea and from there attempting to solve the problems of sea storms and changes ... There (above) is the laboratory of weather, there clouds are formed, there they move, and there measuring instruments seldom are placed. There will come a time when an aerostat will be as permanent an instrument of the meteorologist as the barometer has become." And now we see how brilliant has been the scientific forecast of D. I. Mendeleyev,

inasmuch as aerological observations have become systematic, and the greater part of them is based on the utilization of aerostats of one type or another.

The results of flights made from 1852 to 1866 by Uelsh and, especially, by Glesher in England were known to D. I. Mendeleyev. On one of these flights an altitude of 8,840 meters was attained, and further ascent nearly cost the lives of Glesher and his companion Koksvell. Evidently, the problem of reaching great altitude was related to the development of a new scheme for the aerostat. "It is possible to rise higher in aerostats than has taken place heretofore," stated D. I. Mendeleyev; for this it is necessary to have "...a space enclosed from all sides in which the observer will remain safe at high altitudes and will manage the ascent and descent of the balloon and, besides, study the conditions of the upper layers of the atmosphere." In this manner, in 1875, D. I. Mendeleyev put forth the idea of a stratostat and developed the principle of a hermetically sealed gondola. D. I. Mendeleyev himself made a successful flight in an aerostat during the solar eclipse of 1887, which also proves the growth of interest by wide circles of society in air navigation and study of the high strata of the atmosphere.

The Czarist government stifled the creative activity of scientists and inventors, did not permit the full development nor the realization of their ideas. Such were the conditions which prevailed with the projects of D. I. Mendeleyev: he did not receive

the necessary means for the construction of an aerostat and was not even able to realize the proposal of sending aloft automatic instruments on small free balloons (which later became radio meteorograph balloons).

The Air Navigation Department of the Russian Technical Society under the chairmanship of M. A. Rykachev, organized in 1880, participated greatly in making flights for the purpose of investigating the free atmosphere. Especially fruitful was the work in this direction made by M. M. Pomortsev, one of the pioneers of Russian aerology. Under the leadership of M. M. Pomortsev and with his participation, lengthy and systematic investigations were made. The results of the first forty flights were processed and published by him in 1891, and in 1897 his second work appeared in the form of a scientific report on 80 flights together with a series of original and far-reaching conclusions.

M. M. Pomortsev was at the same time a leading designer and created a series of meteorological instruments. He also proposed to use the theodolite for observations of cloud movements, proposed the question and supplied the solution for an experimental verification of a barometric formula, utilizing the original method of determining the altitude of an aerostat by measuring the angular diameter of balloons with the micrometer eyepiece of the theodolite. Especially interesting was the analysis, made first by him, of aerological material in connection with synoptical conditions. He was the one who in 1889 wrote the first Russian textbook on synoptical meteorology.

In addition, M. M. Pomortsev, S. I. Savinov, V. V. Kuznetsov, and others made separate flights on aerostats.

Later than in Russia, a series of aerological flights on aerostats was made in Germany, beginning with 1891, by Assman, Berson and Zyuring; a compendium of the results of their observations was published only in 1900.

When making observations from aerostats, the principle difficulties arose in taking temperature measurements. The discovered influence of solar radiation upon thermometer readings was overcome by way of ventilating the thermometer bulb. The Russian scientists M. A. Rykachev and M. M. Pomortsev utilized with success a sling thermometer. Uelsh used in his observations an aspiration thermometer, and later, Assman, a ventilating psychrometer.

In the next phase of the development of aerology, the beginning of which was at the end of the nineteenth century, appeared the use of flying apparatus for studying the atmosphere with instruments which automatically recorded changes in meteorological elements with altitude.

For this, in the practice of aerological observations, the methods of kite ascents, of sounding balloons, and ascents in captive balloons were introduced. The utilization of these convenient and inexpensive methods permitted the systematic sounding of the atmosphere at a series of points without necessitating such

complex and expensive means as free aerostats, the flights of which, therefore, could not assure regularity of investigations.

In Russia, systematic aerological observations were organized by the Main Physical Observatory -- the central government meteorological organization.

The method of sounding balloons developed out of the method of free aerostats. In the beginning, releases of small aerostats equipped with self-recording instruments without observers were organized. Later, special balloons heavy enough to lift light instruments were designed. Experiments in the use of such sounding balloons began to be conducted in 1892.

Initially, for this purpose, cloth or paper casings were used of various sizes -- having diameters from several meters to dozens of meters. They were filled mainly with hydrogen. The first ascent of a sounding balloon in Russia occurred in 1896 near Leningrad at the Aeronautical School. This sounding balloon was an aerostat (nicknamed "Kobchik") with a volume of 250 cubic meters. Systematic ascents of sounding balloons began to be made in our country at the Pavlovsk Observatory from 1901.

The widespread use of the sounding balloon method was due to the appearance of rubber casing (1901), which simplified the technique of ascents and increased the altitude of soundings. The discovery of the stratosphere made by Teyseran de Borom (France) in 1902 is due to the sounding balloon method.

At the end of the nineteenth century appeared the method of pilot balloon observations for investigating winds in the free atmosphere. However, its widespread use was possible also only after the appearance of rubber casings, i.e., in the beginning of the twentieth century.

The use of kites for aerological investigations began during the nineties of the last century. The technique of building kites in Russia was at a high level. It is enough to mention the names of A. F. Mozhayskiy (the inventor of the world's first airplane), S. S. Nezhdanovskiy and S. A. Ulyanin, who built kites of great capacity and stability of flight at the end of the nineteenth century. The first aerological kites were flown in Russia in 1897. These ascents were organized by the Main Physical Observatory in Pavlovsk (near Leningrad) with the purpose of determining the height of clouds. Soon thereafter, meteorological instruments began to be sent aloft on kites there, and from 1899 kite observations became the basic means of atmospheric soundings.

V. V. Kuznetsov was engaged in the development of kite observation methods. The initial period of our aerology and the development of the first aerological instruments, used in our country for a long time, were closely linked with his name. These instruments included the aerological theodolite, nephoscope, kite and sounding meteorographs, wind gust meters and others, as well as semi-cylindrical kites with excellent flying qualities. In 1902, under the leadership of V. V. Kuznetsov, a Kite Department at the

Pavlovsk Branch of the Main Physical Observatory was established; later (in 1912) this was reorganized into the Aerological Observatory.

An International Aerological Commission, organized in 1896 for the coordination of aerological investigations, established international days for simultaneous observations at all points. These observations had great value for the development of ideas on the structure of the atmosphere. M. A. Rykachev, M. M. Pomortsev and V. V. Kuznetsov were active participants in these international investigations and organizers of countless observations at various points in Russia.

Aerological observations with the aid of kite and sounding ascents began to be made in the first years of the twentieth century at Kazan', at the Aerodynamic Institute in Kuchin (near Moscow), at the Yekaterinburg, Tiflis, and Irkutsk Observatories, and several other points. Local observatories took part in international aerological observations. However, regular soundings were made only at Pavlovsk, where the work on methodology of aerological investigations and dissemination of the results of observations were concentrated.

Thanks to the determination and love of their work by the scientists, notwithstanding the difficulty of the work under the conditions of Czarist Russia, Russian aerology attained considerable successes. Several basic methods of aerological investigations (with the aid of aerostats, sounding balloons, kites, and pilot

balloons) were developed, instruments were designed, systematic observations in Pavlovsk and periodic observations at a number of other points were organized. A study of the results of observations gave the opportunity of obtaining the first information on the temperature regime of the lower layer of the free atmosphere, on the average distribution of temperature at various altitudes, and on the height of the lower limit of the stratosphere for certain points. The study of the results of soundings from the synoptical point of view was continued. A. A. Fridman completed the first work on the theoretical study of the free atmosphere.

4. Development of Aerology in the USSR after the Great October Socialist Revolution

The development of investigations in the field of aerology, as in other fields of science, in prerevolutionary Russia was made difficult by the policy of the Czarist government, which stifled the creative activity of the investigators by not granting them means and by not supporting the initiative of the talented sons of the Russian people. Only the Great October Socialist Revolution established the necessary conditions and material possibilities for the flowering of science and technology, and, in particular, for the development of aerology.

In relation to the important problems confronting Soviet meteorology in 1921, V. I. Lenin signed a decree of the Soviet of People's Commissars of the RSFSR "On the Organization of Meteorological Service in the RSFSR", determining the mission of the

meteorological service in serving the national economy of our country. The acceptance of the national economic plan of the first Five-Year Plan and the consequently increased demands upon meteorology and hydrology necessitated the unification of the entire hydro-meteorological service of the country. In 1929, the Soviet government organized the Hydro-Meteorological Committee of the USSR under the Soviet of People's Commissars of the USSR. In accordance with this, the conditions and the field of meteorological work embraced were basically changed.

The first successes of Soviet aerology are related to the activity of the Pavlovsk Aerological Observatory. At the same time, work in the field of aerology was developing in Moscow, where in 1929, within the organization of the State Scientific-Research Geophysical Institute, the Moscow Aerological Observatory was established.

The Pavlovsk observatory was the scientific-methodological center which developed new methods of aerological investigations and more advanced designs of instruments. These included the widely used instruments for the processing of pilot balloon observations -- Molchanov's circle, the sounding meteorograph without a clock mechanism, the pilot balloon self-recording theodolite, kite and airplane meteorographs, kite and captive aerostats of new designs and a series of other improved equipment created by the collective of scientific workers of the observatory. The program of aerological observations of the observatory was greatly

expanded. Finally, under its leadership in 1924, the first pilot balloon stations in various points of the Soviet Union were opened.

The method of airplane soundings of the atmosphere was proposed by A. A. Fridman as early as 1916, but it was developed only after the Great October Socialist Revolution. With this view, an airplane meteorograph was designed at the Pavlovsk Observatory in 1921-1922.

The wide application and development of the method of airplane soundings was attributed to the Moscow Aerological Observatory.

On the initiative of V. I. Vitkevich, airplane soundings began in 1921 in Moscow, for which, notwithstanding the difficulties of the times, the Soviet government assigned an aviation unit to the observatory. In October 1924, an altitude of 8,560 meters was attained -- a record for airplane soundings for that period. Besides airplane ascents, beginning with 1919, kite and pilot balloon observations and, later, captive aerostats and sounding balloon flights were organized. In Moscow, the first acoustical methods of investigating the atmosphere in the USSR were applied by V. I. Vitkevich.

In the organization and development of the work in the field of aerology in the Moscow Observatory, large roles were played by S. L. Bastanov and V. A. Khanevskiy.

The demands of the national economy, the development of aviation, the needs of the weather service all required an intensified growth of investigations of the free atmosphere in the USSR.

One of the missions of the Hydro-Meteorological Committee organized in 1929, was the organization of a net of aerological stations, in a great measure due to the development of the weather service, which by that time was using new ideas in synoptical thought, requiring data on the conditions of the free atmosphere for the analysis of weather forecasts. The existing network of pilot balloon observations was not able to satisfy these requirements. Information on the distribution of temperature and humidity was necessary. This problem could not be solved by the method of airplane soundings because of the dependence of flights on the weather and their considerable cost.

The study of polar regions, the conquest of the stratosphere, the increased requirements of the quickly developing Soviet aviation -- all these called forth the necessity of establishing new operational methods of soundings which satisfied recent requirements.

Having in mind the satisfaction of these non-postponable requirements and the general development of the study of the atmosphere, the collective of the Pavlovsk aerological observatory under the direction of P. A. Molchanov, worked out a new method of investigating the free atmosphere -- the method of radio soundings.

The first radio sounding in the world, made on 30 January 1930 at Pavlovsk, affirms the leadership of our motherland in this most important contemporary sounding of the atmosphere, beginning a new phase in the development of aerology. [redacted] Prerequisite to this invention were the great successes of Soviet radio technology.

Only after the beginning of regular ascents of radio soundings in the USSR, did the first radio soundings appear in France and Germany and considerably later in the United States.

The first period of the work of the Pavlovsk aerological observatory ending with the invention of radio soundings is characterized also by a series of other important works in the field of observational methodology, as well as in the field of physics of the free atmosphere. From the methodological works, it is desirable to point to the experimental research on the influence of turbulence on the vertical velocity of pilot balloons, the development of a method for measuring wind gusts in the free atmosphere, and the introduction of systematic pilot balloon observations.

The materials of observations allowed further development in the work of determining more precisely the structure of the free atmosphere. A series of new factors were established, such as, spring inversion, types of distributions of gusts; icing on kites and conditions of cumulus cloud formations were studied; detailed characteristics of the changes of wind with altitude, etc, were obtained.

The radio sounding method provided the possibility of establishing a net of aerological stations for temperature soundings, which was organized by the Hydro-meteorological Service of the USSR beginning in 1934. The development of the net of aerological points of temperature and wind soundings and their regular work permitted the development and introduction of adiabatic charts and altitude charts into the practice of the weather service. This resulted in assuring the successful development of new synoptical methods -- in particular the advective-dynamic analysis as worked out by Kh. P. Pogasyan and N. L. Taborovskiy, and the hydrodynamic method of weather prediction established by N. E. Kochin and I. A. Kibel.

Further, the work of the Pavlovsk aerological observatory entered the field of perfecting radio soundings, the establishment of new types of meteorographs, the adaptation of radio location for the measurement of wind when there is an absence of visibility, the solution of problems on the precision of aerological methods in the measurement of wind, temperature, and pressure. The result of the work was the appearance of a series of newly designed instruments such as a commutator radio sounder, a stratostatic meteorograph, and others. In 1933, for the first time, an automatic meteorological station was built.

At the same time, the Pavlovsk observatory was responsible for the direction of the established network of aerological stations.

This observatory plays an important role in the preparation of aerology personnel. Over a number of years, special courses at the observatory prepared aerologists for work in the network of aerological stations. Here students of the Moscow (later Leningrad) Hydro-meteorological institute, the Leningrad University, and other educational institutions preparing specialists in the field of aerology had their practical training.

The Moscow aerological observatory also successfully carried on investigations of the free atmosphere by all types of aerological soundings. Among the new instruments developed by this observatory, the self-recording theodolite with constant registration of angles and the first rocket meteorograph should be mentioned. The work on the attainment of high altitudes of sounding was brought to successful ascents of balloon soundings up to an altitude surpassing 30 kilometers.

Gradually, the role of local observatories (Sverdlovsk, Tbilisi, Odessa, Kiev and Minsk) increased.

According to the accumulation of material on aerological observations at the Pavlovsk and the Moscow aerological observatories, as well as in geophysical observatories, the problems of the physics of the free atmosphere are being more thoroughly investigated. There, a series of problems is being solved with the aid of especially developed methods of observation.

From year to year, the role of aerology in the fulfillment of requirements and problems of the national economy is steadily rising.

Soviet aerologists are participating greatly in the study of the stratosphere. Scientists began to give special attention to this question from the beginning of the thirties; at this time the work on the study of the troposphere and the lower atmosphere first appeared.

The great rise of Soviet science and technology and the heroism of the Soviet people were demonstrated by the successful flight of the stratostat "SSSR-1" and the "Osoaviakhim-1". The first flight (Stratostat "SSSR-1") took place on 30 September 1933.

Aerial navigators G. A. Prokof'yev, K. D. Godunov, and E. K. Birnbaum attained altitudes of 19 kilometers. The second flight (on the stratostat "Osoaviakhim-1") was held in 1934 with a crew consisting of P. F. Fedoseyenko, A. B. Basenko, and N. D. Usyskin; the stratostat attained the record altitude of 22 kilometers.

These flights, like those that followed, added greatly to the knowledge of the stratosphere, their results surpassing foreign investigations.

The development of methodology of investigations and the successful construction of scientific instruments were achieved by the collective of the Main Geophysical Observatory (S. I. Savinov, N. N. Kalitin, P. N. Tverskoy, and others).

Investigations of the stratosphere were not limited by work on the basis of aerological observations and flights of stratostats.

As was pointed out, the study of upper layers was being carried on by indirect methods. V. G. Fesenkov in 1923 proposed the utilization of observations of the brightness of twilight; this work was further developed by N. M. Shtaube, and in recent years it is being conducted by a series of astrophysical observatories of this country.

Since 1932 M. A. Bonch-Brunyevich and P. N. Tverskiy have successfully conducted investigations by the method of radio wave distribution. In recent years, while investigating the distribution of radio waves, a series of basic conclusions on the physical properties of the ionosphere were made by V. L. Ginsburg and Ya. L. Al'pert.

Observations of silver clouds, meteors, and the contents of the ozone also gave rich materials for the study of the stratosphere. A considerable contribution to the study of upper layers was made by N. A. Khvostikov on the basis of observations of the illumination of the nocturnal sky and results of projector soundings.

A conference on the study of the stratosphere, held in 1934 under the direction of S. I. Vavilov, summed up the work in the field of study of upper layers of the atmosphere, showing the value and fruitfulness of the extensive investigation of the problems of the stratosphere conducted by Soviet scientists.

The requirements of synoptical meteorology by the detailed study of synoptical objects and processes demanded the organization

in 1939 and 1940 of special soundings, more frequent in time and space. These soundings gave valuable material for use in the construction of synoptic-aerological cross sections of the atmosphere. Such work and other investigations in the application of aerological data in synoptical practice represented the development of aerological work begun as early as the twenties at the Main Geophysical Observatory (by S. I. Troitskiy and others).

In 1940 the Moscow aerological observatory was attached to the Central Forecasting Institute. As a result of this, its work took on a definite synoptical direction. The strengthening of the technical base of the observatory was a great achievement. The observatory obtained control of a fleet of free aerostats and qualified air navigators. Utilization of these means made it possible to conduct a variety of experimental investigations in the free atmosphere.

The great fatherland war placed new problems before the hydro-meteorological service of the USSR, and before aerology particularly.

With self-negating labor, Soviet aerologists fulfilled their missions at the front and in the interior zone. The work of the aerological observatories of the GGO and TsIP continued on the preparation of aerological instructions, on the investigation of the accuracy of aerological methods, on the improvement of direction finding of radio pilot balloons, as well as the methodological management of production of radio soundings, casings, etc.

During these years, a series of new methods and instruments was also developed. Thus, in the Moscow Aerological Observatory, the world's first regular observations of the wind in the free atmosphere with the aid of a radio locator (the so-called radio-pilot observations) were established. The Central Design Bureau (TsKB) of the Main Administration of the Hydro-Meteorological Service worked out a new airplane meteorograph, Sm-43, and a new radio-sounder, "Volna".

The reconstruction and development of socialist economy in the post-war period raised greater practical problems and demanded more intense effort on the part of workers of the hydro-meteorological service, especially aerologists. The re-establishment of the aerological network and its development in connection with the application of new methods of synoptical meteorology, the scientific-methodological direction of the increased network of aerological stations, the development and broadening of investigative work in the field of methodology of aerological observations and physics of the free atmosphere -- all of this posed the problem of independent direction by the aerological center. Accordingly, the Moscow Observatory in 1943 was redesignated as the Central Aerological Observatory (TsAO). It was strongly fortified and developed in succeeding years, and at the present time is a large scientific institution of the system of the Hydro-Meteorological Service.

We are indebted to the activity of the TsAO for the further development of the aerological network, for the introduction of

radio-pilot observations, for the working out of the methodology of soundings on high-speed aircraft and captive balloons, for the basic improvements of aerial navigation applicable to the problems of aerology, and others. Investigations in the most important problems of contemporary aerology demanded the development of the methodological aspect and a broader physical study of the results.

Special investigations of the stratosphere brought large successes and received high praise from the government. For investigations in the field of cosmic rays, the Stalin Prize was awarded to S. N. Vernyy; for the development of aerological instrument, to the Director of the TsAO, G. I. Golyshev; for the development of new methods of investigating the upper layers of the atmosphere, to I. A. Khvostikov, B. L. Dzerzeyevskiy, and other scientists.

As can be seen from this short review, the development of Soviet aerology proceeded along a completely independent route, in many instances earlier than abroad. The results of aerological investigations always answered to practical necessities and requirements of the national economy and aided the development of meteorology.

The successes of Soviet aerology once more affirm those wide possibilities for the flowering and development of science in our country which our Soviet government and the Communist Party gave, inspiring the Soviet people toward new achievements in all fields of peaceful constructive labor.

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