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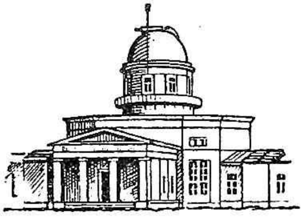

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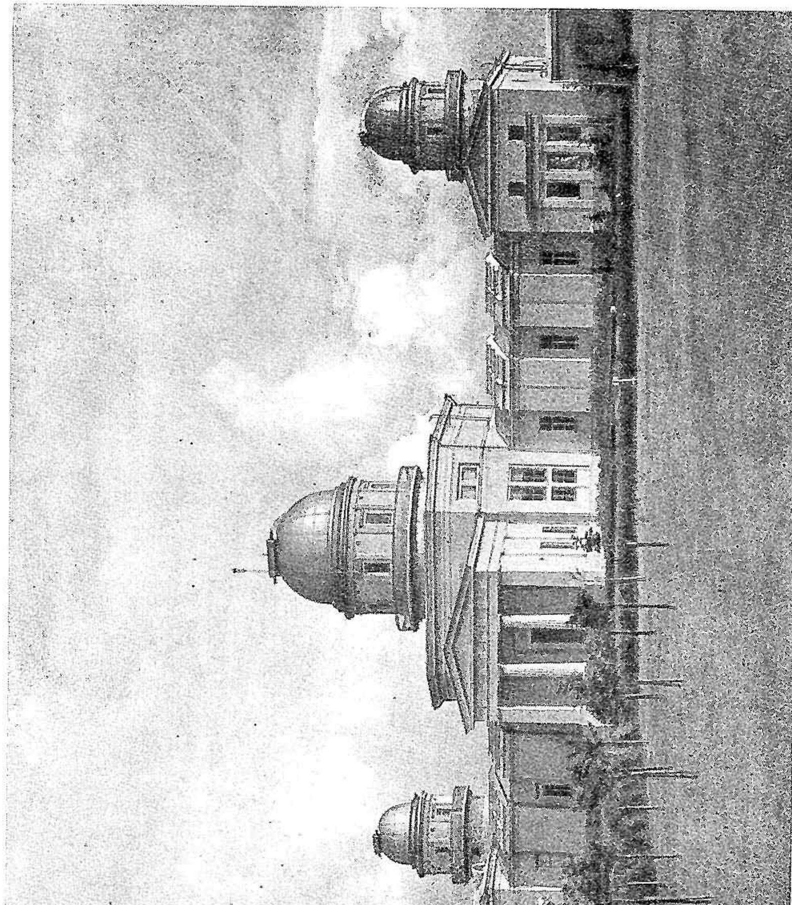

ACADEMY OF SCIENCES OF THE USSR
CENTRAL ASTRONOMICAL OBSERVATORY

A. N. DADAEV

THE PULKOVO OBSERVATORY

ACADEMY OF SCIENCES OF THE USSR PRESS
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THE HISTORY OF THE OBSERVATORY

The Pulkovo Observatory was founded by an outstanding astronomer of the nineteenth century, F. W. Struve (1793—1864). It was built according to the design of the well-known Russian architect, A. P. Brüllow (1798—1877). The official ceremonious inauguration of the observatory took place on August 19 (7), 1839.

The founding of a first-class astronomical observatory of the Academy of Sciences was dictated by the practical needs for a geographical study of the vast territory of the Russian Empire, which was then on the way to capitalistic development. The newly built observatory was equipped with the most perfect instruments of those days, these being ordered by F. W. Struve in foreign countries.

The main task of the observatory was the determination of the exact coordinates of celestial bodies in order to compile star catalogues. This problem was solved by the absolute and differential methods of observation. More precise values of astronomical constants were also derived from the data thus obtained.

In order to determine the absolute coordinates of stars, independently of any other previous measurements, F. W. Struve proposed that the right ascensions and declinations of the stars be observed separately. For this purpose a large transit instrument (the diameter of the object-glass $D=150$ mm, $f=260$ cm) and a vertical circle ($D=150$ mm, $f=195$ cm), made by Ertel in Munich, were installed. The differential observations were made with a Repsold meridian circle ($D=150$ mm, $f=215$ cm). The constants of aberration and nutation were determined with a Repsold transit instrument ($D=155$ mm, $f=235$ cm) in the prime vertical. The method of determining the astronomical constants was elaborated by F. W. Struve, who made these observations himself. A 15-inch refractor, the largest in the world at that time, was installed for measurements of double stars. This instrument was made by Fraunhofer's successors — the German opticians Merz and Mahler.

F. W. Struve not only determined the aims and problems of the observatory but also the whole organization of its work, this being fixed by the Statute of the Central Astronomical Observatory.

At first the scientific staff of the observatory consisted of the director (the first astronomer), F. W. Struve, and his four assistants: O. W. Struve, G. Sabler, G. Fuss and C. A. F. Peters. By a skillful use of the first-class equipment and a constant perfection of the methods of observations they pioneered new paths in observational astronomy and founded the Pulkovo astrometrical school where the «art of observation» was combined with the «science of observation».

Executing the main task of the observatory the generations of Pulkovo astrometrists compiled absolute catalogues of right ascensions and declinations of stars for the epochs 1845, 1865, 1885, 1905, and 1930, which included from 374 to 558 bright stars. With the publication of the catalogues of 1845 and 1865, it became possible to compile on their basis fundamental catalogues of star positions, using also the observations of other observatories. Such work was done in the seventienth years of the past century in the USA and Germany (S. Newcomb, A. Auwers, L. Boss). The Pulkovo catalogues, distinguished by their exceptionally high precision, are used even now for the compilation of fundamental systems, invariably with the largest weight.

With the development of astrophotography a program was put forward at Pulkovo for the compilation of an absolute catalogue including stars exclusively of the magnitudes 5—7, uniformly distributed over the sky (one star for every 25 degrees) from the north pole to —15°. This program served as a basis for observations with the transit instrument and vertical circle of the 1900 catalogue. In 1909 at the International conference in Paris the Pulkovo program, proposed by O. A. Backlund, was accepted as an international program, supplemented by Hough, then the director of the Cape Obesrvatory, with stars of the southern sky. Later the observations of stars of the Backlund—Hough list made with meridian instruments of many observatories (Pulkovo, Nikolayev, Greenwich, Cape, Washington and others) served as a basis of the extensive and high-precision catalogues of 1915 and 1925.

However the compilation of star catalogues was not the only aim of observations made by Pulkovo astronomers. They also carried on classical investigations dealing with other problems of astronomy: the determination of the astronomical constants of precession, nutation and aberration, the study of the refraction of light in the Earth's atmosphere, the determination of stellar parallaxes (the distances to the stars), the determination of the peculiarities of stellar motions in connection with the motion of the solar system in space, etc.

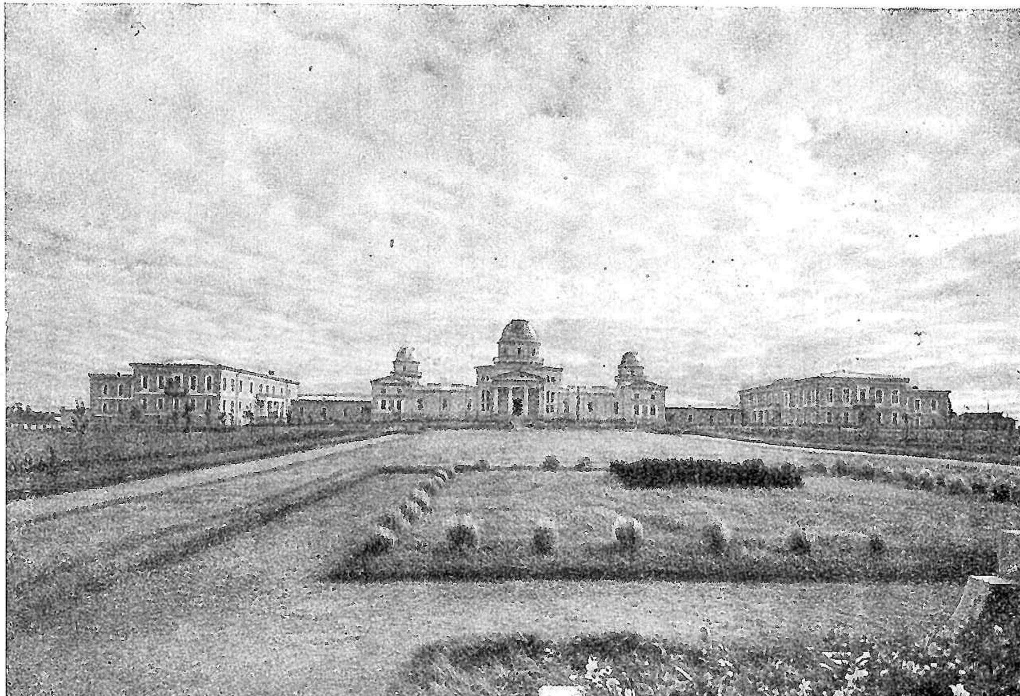
So, in 1842 C. A. F. Peters and G. Lundahl printed the results of the determination of the constants of aberration and nutation, derived from observation made by

F. W. Struve and E. Preiss in Dorpat (now Tartu, Estonia) during 1822—1838. That same year O. Struve published a paper on the determination of the precessional constant from a comparison of the Dorpat observations with Bradley's catalogue. In 1843 a memoir by F. W. Struve, which contained a reduction of observations with the transit instrument in the prime vertical, was edited. The value of the constant of aberration which he derived is very close to the value accepted at present. All the above investigations established a system of the main asrtonomical constants, which needed revision only after 50 years.

In 1846 C. A. F. Peters printed an article in which the absolute parallaxes of eight stars were determined from observations with the vertical circle. In 1847 an investigation by F. W. Struve «Studies in Stellar Astronomy» was published in book-form. In it considerations on the structure of the Milky Way, the motion of the Sun among the stars and evidence for the existence of light absorption in interstellar space were given.

On the basis of the theory, previosly elaborated by the Pulkovo astronomer H. Gyldén, A. I. Gromadzsky compiled the «Tables of Refraction of the Pulkovo Observatory» in 1870. These tables have been published four times and even now they are the main tables used in all astronomical and geodetical works for correcting the observed star positions for refraction in the Earth's atmosphere.

The Pulkovo Observatory played a very active part in the geodetical and geographical undertakings in Russia. It is sufficient to mention the classical measurements of the arc of the meridian, 25°20′ in length, between the Danube and the Arctic Ocean. This was the longest arc measured up to that time and even now would be considered a very large enterprise. The Pulkovo astronomers also took part in other extensive arc measurements, including those made on Spitzbergen in 1899—1901 — the most



Main building seen from the North.

northern triangulation in the world, which was accomplished jointly with the Swedish Academy of Sciences.

Before the revolution the Pulkovo Observatory was the only scientific and higher institution in Russia at which geodesy was cultivated. Here the military geodesists completed their training. It was only after the 1917 October revolution, with the foundation of a series of geodetic institutions, that its former extensive scientific and educational activity in geodesy became unnecessary.

Together with the development of astrophysics as a science in the second half of the last century work in this field was started at Pulkovo. The Pulkovo astronomers made a series of pioneer investigations in astrophysics, contributing considerably to the perfection of its methods and gave indisputable conviction to its very interesting results which attracted universal attention.

The beginning of astrophysical investigations can be connected with the observations of solar eclipses to which Russian astronomers attached great importance since the days of Lomonossov. From observations of the 1851 solar eclipse O. Struve concluded that prominences and the corona are not optical phenomena, as was supposed formerly, but should be considered as composite parts of the Sun itself.

In the sixtieth years the Pulkovo Observatory acquired some astrophysical equipment. P. Rosén and E. Lindemann made many measurements of the magnitudes of stars, including variables, with a Zöllner photometer. In 1876 B. Hasselberg founded an astrophysical laboratory for which a special building was erected in 1886. Along with astrophysical observations of celestial bodies Hasselberg made observations in the laboratory of the emission spectra of various elements and chemical compounds. In particular, the study of the spectra of comets and carbon compounds

General view from the South.

led to his publication of the first monograph to be printed dealing with this problem.

Astrophysics at Pulkovo acquired «civil rights» in full measure when one of the greatest Russian astronomers, Th. A. Bredichin (1831—1904), became director of the observatory in 1890. From this time also A. A. Belopolsky (1854—1934), who to the end of his days headed the astrophysical investigations at Pulkovo, began his fruitful work.

The directors of the observatory (after F. W. Struve this post was occupied by his son — O. Struve, then Th. A. Bredichin and O. A. Backlund) paid constant attention to the acquirement of new equipment and instruments. Of the most significant acquisitions the following should be mentioned: a 30-inch refractor with an object-glass made by A. Clark (mounted in 1885), a normal astrograph (mounted in 1893, object-glasses: photographic $D=330$ mm, $f=345$ cm, visual $D=250$ mm, $f=350$ cm), the so-called Bredichin astrograph ($D=170$ mm, $f=80$ cm, a gift given by Bredichin to the Pulkovo Observatory and mounted in 1905) and the zenith telescope ($D=135$ mm, $f=175$ cm, made by G. A. Freiberg-Kondratyev, a mechanic at Pulkovo).

Latitude observations with the zenith telescope have been carried on regularly since 1904. These observations were interrupted by the war and resumed in 1948.

The mounting of the normal astrograph at Pulkovo inaugurated its work in photographic astrometry. These studies were headed by S. K. Kostinsky (1867—1936) who left a rich collection of photographic plates. His followers succeeded in preserving these plates and after tens of years used them for deriving the proper motions of stars and clusters, for studying wide star pairs and the peculiarities of motion of double stars, in particular 61 Cygni.

With the normal astrograph and an enlarging camera A. P. Hansky took remarkable unrivalled photographs of sunspots and granules. These were of such detail and quality that they were not surpassed until only recently.

The Bredichin astrograph enabled G. A. Tikhov to accomplish his photometric and colorimetric investigations of stars with which he was occupied during many years. For studying the colour indices of stars G. Tikhov elaborated the method of the «longitudinal spectrograph» in 1916. Using this method he determined the colours of all the Bonnerdurchmusterung stars in 91 Kapteyn areas.

G. Tikhov photographed the planets through light filters with the 30-inch refractor. The photographs of Mars, taken by him at Pulkovo during the great opposition in 1909, induced him to further investigations in this field and in 1947—1948 led to the well-founded conclusion of the existence of vegetation on Mars and the birth of a new branch of astronomy — astrobotany.

The development of astrospectroscopic investigations in Russia is closely connected with the name of A. A. Belopolsky. He was a pioneer in the elaboration of the method for determining the radial velocities of stars. Using the 30-inch refractor, to which he attached a three-prism spectrograph, Belopolsky determined the radial velocities of many stars in order to compile a catalogue. During this study he investigated several spectroscopic binaries, detected the variability of radial velocities of Cepheids, observed outbursting Novae, etc. He found the period of rotation of the Sun, major planets and Saturn's rings and observed the spectra of comets.

In 1894 A. Belopolsky experimentally corroborated the Doppler-Fizeau effect for light. He also made laboratory experiments, studying the spectra of glow discharges of gases and published a paper on the investigation of the glow discharge spectra of Geissler tubes. He paid much attention to the construction of spectrographs and other instruments.

The 1917 February and October revolutions found Belopolsky at the post of the director of the observatory. He actively participated in the organization of the All-Russian Astronomical Society formed in April 1917. The organization of such a society was of great importance as most of the work done at the Pulkovo Observatory, was isolated from that of other Russian observatories.

Two institutions were under the supervision of the Pulkovo Observatory — its branches in Nikolayev (the Ukraine) and Simeiz (Crimea). The former was organized in 1898, first in Odessa, and moved to Nikolayev in 1909, when the Observatory of the Naval Department founded in 1821 in Nikolayev was passed over to the Pulkovo Observatory. The Nicolayev Observatory played an important part in the development of astrometrical work. To the present day it is a branch of the Pulkovo Observatory and carries on investigations according to a common plan.

The Simeiz branch was developed from an amateur observatory of an honorary member of the Academy of Sciences, N. S. Maltsev, who presented it together with a piece of land to the Pulkovo Observatory in 1908. From the very beginning the Simeiz branch specialized in astrophotographic and astrophysical observations.

The great October Revolution marked not only a political and social-economical revolution but was also a turning point in the development of science which beneficially affected the activites of the Pulkovo Observarory.

In spite of economical difficulties, which our country underwent after the imperialist and civil wars, the Soviet Government affirmed the orders made in England in 1912 of a 40-inch reflector and 32-inch refractor for the Simeiz and Nikolayev branches. The firm of Grubb-Parsons, which was fulfilling these orders, was assignated additional sums.

Besides, a large solar spectrograph of the Littrow system with auxiliary optical parts (coelostat with a diameter of 250 mm, two additional mirrors and an object-glass, $D=200$ mm, $f=1280$ cm) was bought in England in 1922. This instrument enabled A. A. Belopolsky to develop in full measure the investigations of the Sun.

The Simeiz 40-inch reflector began to operate in 1925. On it (up to the occupation of the Crimea by the enemy-fascist forces in 1941—1944, during which the telescope perished) much work was done on the compilation of a catalogue of radial velocities and investigations of special problems of the spectroscopy of stars (G. A. Shajn, V. A. Albitsky).

In 1927 the Pulkovo Observatory acquired yet another instrument — a zonal Zeiss astrograph ($D=160$ mm, $f=205$ cm), which at the end of the thirties was transferred to Simeiz. During these years the observatory was reinforced with various other equipment. The firm of Grubb-Parsons made and sent to the USSR only the mounting and mechanical parts of the 32-inch refractor, as the numerous attempts to make the object-glass were unsuccessful. In 1940 the necessary object-glass was made by the Soviet optical industry, which developed during the years following the revolution.

In 1919 in accordance with the new rules an election was held for choosing a director of the observatory. There were two candidates: A. A. Belopolsky and A. A. Ivanov, then the rector of the Petrograd University. Before the elections A. A. Belopolsky withdrew his candidature and A. A. Ivanov was elected. He was re-elected twice and held the post of director till 1930.

The rules for the election of a director and all the scientific posts were fixed by the Statutes of the Central Russian Astronomical Observatory, introduced in 1921. According to the new statutes the Council of Astronomers received more rights and the administrative activities were regulated by a special committee.

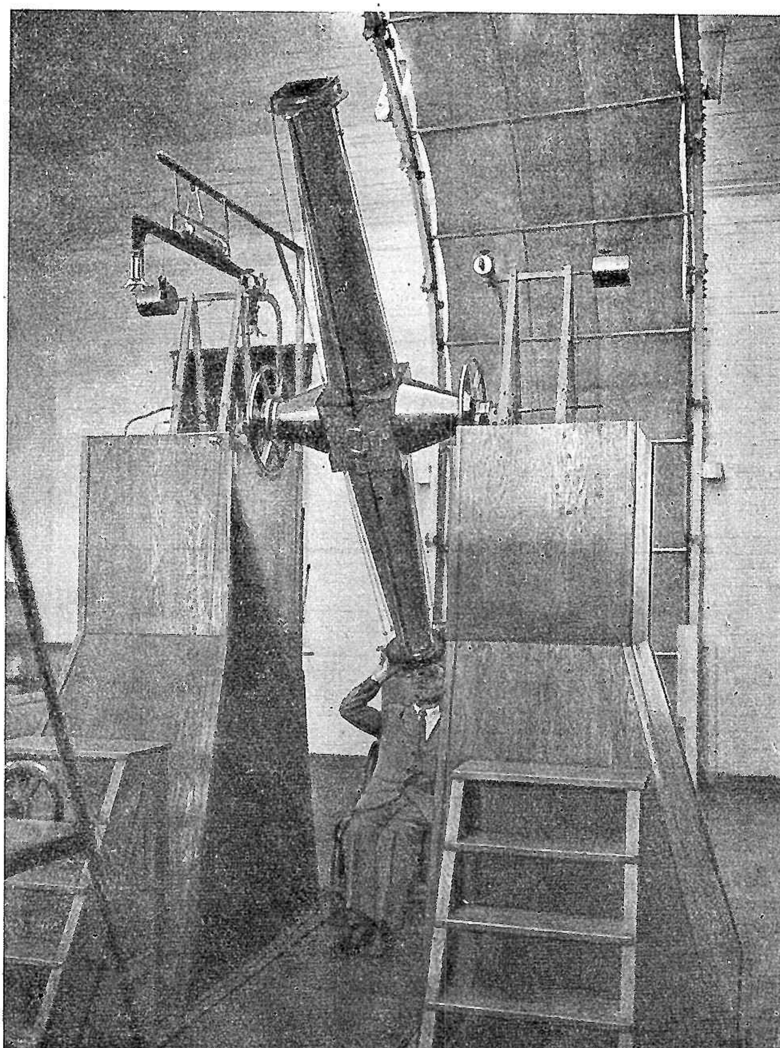
The Council of Astronomers drew-up a new list of scientific posts for the observatories, which was then confirmed by the Academy of Sciences of the USSR. Already in 1925 the number of scientific, technical and administrative personnel (excluding the two branches) reached 60, as compared to 20 in 1913. In 1925 with the establishment of courses for aspirantes the preparation of scientific personnel changed essentially.

In the first years after the revolution, as a result of the inflow of young astronomers to the observatory, the Pulkovo schools of astrophotography, astrospectroscopy and astrophotometry, founded by S. K. Kostinsky, A. A. Belopolsky and G. A. Tikhov, were greatly enlarged.

Work which was of great significance for national economy assumed ever increasing importance. So in 1920, on the initiative of A. A. Ivanov, signals of exact time were transmitted regularly from Pulkovo through radio stations of Leningrad and Moscow. The reduction of series of latitude observations made with the Freiberg-Kondratyev zenith telescope served for the further development of the Service of the Coordinates of the Pole and supplied valuable data for theoretical investigations.

The enlargement of old observatories, as well as the founding of new astronomical institutes and observatories in the country, demanded better planning and coordination of astronomical investigations. This led to the organization of the Astronomical Council of the Academy of Sciences of the USSR in 1937. Astronomers from Pulkovo headed some of the various commissions connected with the general planning of work of the observatories.

A result of jointly planned work of several observatories is «The Catalogue of 2597 Bright Stars with Declinations from —10° to +90°», which being of practical impor-



The Ertel transit instrument.

tance became widely-known as the catalogue of «geodetical stars» (this work was headed by N. V. Zimmerman). In 1932 the Pulkovo astronomers proposed another collective undertaking — the observaton of «The Catalogue of Faint Stars», containing the exact positions and proper motions of about 20 000 stars uniformly distributed over the sky. Many astrometrists, especially those of the Sternberg Astronomical Institute in Moscow, took part in working-out the program of the new large catalogue.

An essential feature in this new work is the determination of the proper motions of the stars by their photographic reference to galaxies. For the derivation of a uniform system of declinations and the determination of the point of the equator the observations of selected minor planets are used. Photographic and meridian observations according to the program of the «Catalogue of Faint Stars» were begun at several observatories in 1940 but were interrupted by the war and resumed only during the post-war years.

Other meridian, absolute and differential observations at Pulkovo, which served as a basis for the compilation of a whole series of catalogues, published during 1917—1941 in the Transactions of the Observatory, have already been mentioned.

During 1933—1939 N. N. Pavlov elaborated and applied a photoelectric method for the registration of star transits for the time service. This method received further development and is now widely used.

The photographic plates taken by S. K. Kostinsky were used by his pupil, A. N. Deutsch, who after 20 years photographed the second epoch plates in order to compile a catalogue of proper motions of 18 000 stars. Observations with the zonal astrograph served as a basis for «The Astrographic Catalogue of 11 322 Stars between 70° North Declination and the North Pole» (S. I. Belyavsky).

The role of astrophysical investigations at Pulkovo had grown greatly during these years. The work of Belopolsky on the detailed study of solar rotation, which he undertook after the installation of the Littrow spectrograph, served as a stimulus for the development of solar, in particular spectroscopic and spectrophotometric, investigations.

Great attention was paid to the study of solar activity. In 1932 at the Simeiz branch a photoheliograph for daily observations of the Sun (sunspots and faculae) was installed and in 1938 a spectrohelioscope for observing prominences and the chromosphere. These observations were the beginning of a continuous Solar Service of the USSR, the data of which has been published in «The Catalogue of Solar Activity» since 1938. The study of connections between solar and terrestrial phenomena and the generalization of investigations in this field led to the publication of a monograph «Solar Activity and its Terrestrial Manifestations» (M. S. Eigenson, M. N. Gnevishev, A. I. Öl, B. M. Rubashev) in 1948.

In 1927 an expedition to Sweden was organized for observing the total solar eclipse. Much preparatory work was done for observations of the 1936 total solar eclipse, which passed over a considerable territory of the USSR. All the expeditions were equipped with new, modern apparatus and instruments, made by the young optical-mechanical home industry. The successful results of the observations contributed to the further growth of the the significance of solar investigations.

In 1940 the Pulkovo Observatory acquired a horizontal solar telescope (the diameter of the coelostat mirror $D = 500$ mm, the main parabolic mirror $D = 500$ mm, $f = 1700$ cm), which was made in Leningrad under supervision of the talented constructor and astronomer, N. G. Ponomarev. The optical parts of the telescope were computed and made by

D. D. Maksutov. At that time it was the largest instrument of its kind in Europe.

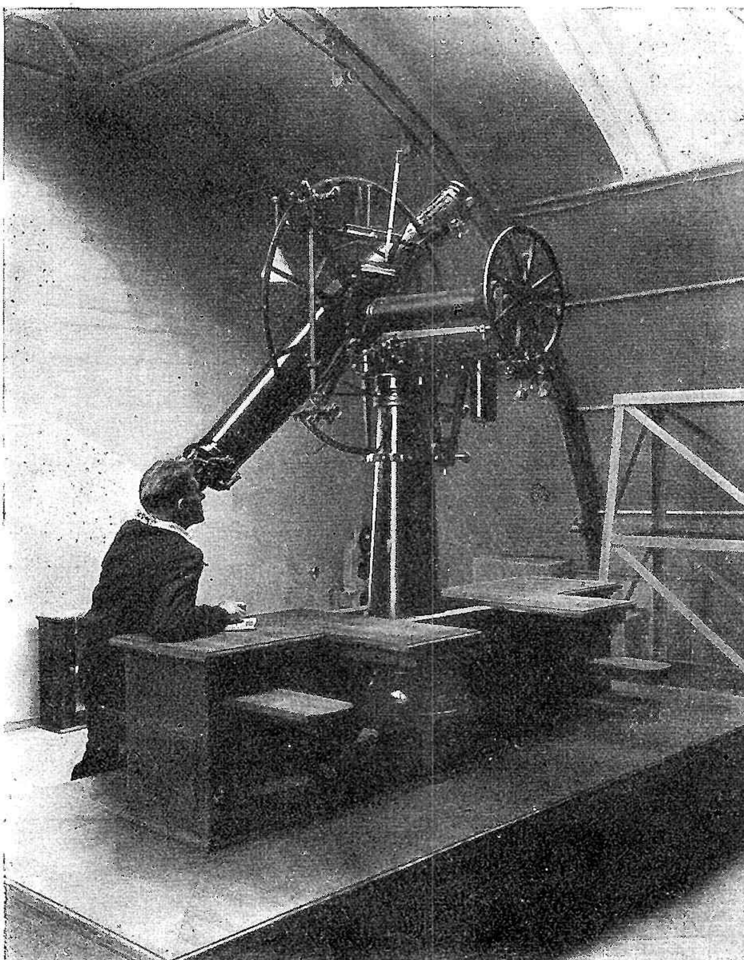
Besides observations of the Sun, large series of photometric and colorimetric observations of stars (G. A. Tikhov, M. D. Berg and others), work in stellar spectroscopy (V. A. Ambartsumian, O. A. Melnikov) and studies of eclipsing variables (V. A. Krat, S. V. Nekrasova) were also carried on at Pulkovo.

The following investigations in theoretical astrophysics were also made during the nineteen thirties: the elucidation of the peculiarities of the emission of planetary nebulae (V. A. Ambartsumian), the elaboration of a theory on extended photospheres of stars (N. A. Kozirev) and the study of the internal structure of stars (B. P. Gerasimovich).

The investigations of the Pulkovo astrophysicists were included in text-books on astrophysics, among which a prominent place is occupied by «A Course in Astrophysics and Stellar Astronomy» in two volumes, written by a group of authors and edited by B. P. Gerasimovich, then the director of the observatory.

In the spring of 1940 the Academy of Sciences noted the centenary of the Pulkovo Observatory by a ceremonious session. Less than one and a half years later the observatory was barbarously bombed from air by the enemy-fascist forces attacking Leningrad.

During two years and four months the observatory was one and a half kilometers from the front line of defence. The enemy did not succeed in capturing the Pulkovo heights but the observatory was constantly under artillery fire. All the buildings of the observatory were completely demolished, the mountings of the large instruments destroyed (their optical parts had been transported to Leningrad together with other smaller instruments). A considerable part of the library, the museum of old instruments, the



The Ertel vertical circle.

belongings of many astronomers, the one hundred years old park, which protected the observatory from winds, also perished.

During the occupation of the Crimea by the Hitlerites the Simeiz branch, near which no fighting took place, was destroyed. The Nikolayev branch suffered relatively little damage, although before their retreat the enemy-fascist forces mined the observatory and prepared it for destruction. Only the heroism of the Soviet forces and the members of the staff, who had remained in Nikolayev, saved it from the fate of the Simeiz branch.

Even before the end of the war, on March 11, 1945, the Soviet Government adopted a resolution that the Central Astronomical Observatory at Pulkovo be rebuilt. The project for rebuilding and reconstruction was carried out under the supervision of Academician A. V. Shchusev (1873—1949). The principal classical features of the main building were left unchanged.

In 1947 when the construction work was still in full swing astronomical observations at Pulkovo were resumed. Former instruments, which it had been possible to save, and new instruments, now made by our optical-mechanical industry on an ever-growing scale, were gradually put into operation.

The Simeiz branch which became a separate scientific institution was rebuilt. On its basis a new observatory was founded in Partizanskoye (near Simferopol) and together with the Simeiz Observatory comprises the Crimean Astrophysical Observatory. The importance of the Nikolayev branch has grown. Near Kislovodsk (Northern Caucasus) a Mountain Station was established as a branch of the Pulkovo Observatory and as a leading institution in the system of the Solar Service of the USSR.

In May 1954 the official inauguration of the rebuilt Pulkovo Observatory took place in the presence of more than 500 astronomers from various Soviet observatories, geodesists, builders of Pulkovo, representatives of the public and also scientists from 18 foreign countries. The observatory was able once again to carry on investigations in various branches of astronomy.

THE OBSERVATORY AT PRESENT

The observatory, situated on a hill 75 meters above sea-level, occupies a territory of 150 hectares. On the north and east it is bordered by the Kiev highway, on the south by grounds where trees and shrubs are grown for the city of Leningrad and on the west by the lands of a live-stock breeding sovkhoz.

To the south-east is the city of Pushkin (formerly Tzarskoye Selo) hidden by parks. The distance from Pulkovo to the city of Pushkin is six kilometers by the road which branches off from the Kiev highway at the foot of the hill. The distance between the main building of the observatory and the center of Leningrad is eighteen kilometers.

To the south-west, rising above the horizon, is the Duderhof hill, the highest point (170 meters above sea-level) in the surroundings of Pulkovo.

To the north Leningrad is visible in the distance. More often it is seen in a haze through which the silhouette of a large city is noticeable. Sometimes, especially during clear autumn days, the blue waters of the Finnish Bay and the golden dome of the St. Isaac Cathedral and the spire of the Petropavlovsky fortress, shining in the sunlight, are discernible on the horizon.

The facade of the main building looks towards the north. It has been rebuilt on its former foundation, keeping the classical forms designed by Brüllow. Only the shapes of the domes are different. Instead of wooden rotating towers with conic roofs there are now brick towers with rotating metallic hemispherical domes.

As before on the top floor under the central tower there is a room for the depot of the scientific library. Beneath the library — a two story hall with a hemispherical ceiling. The center of this is the initial point for all triangulations made in the USSR, its geographic coordinates being: latitude (north) 59° 46′ 18″.7, longitude (east) 30°19′38″.6.

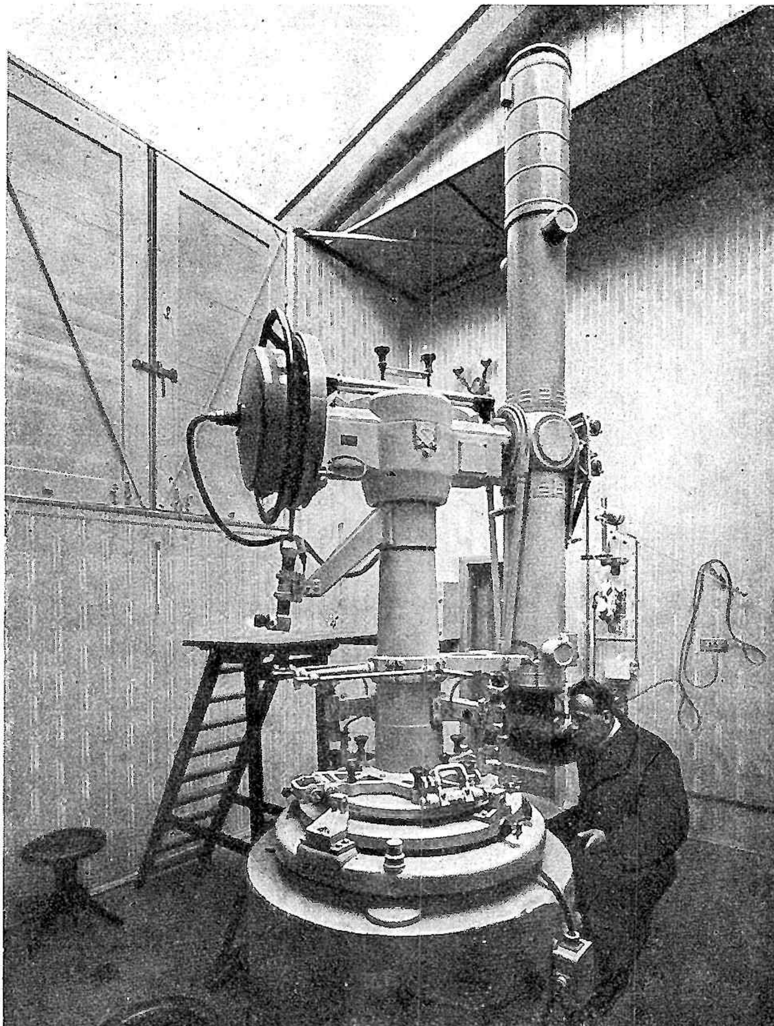
In the central hall there is a portrait gallery of outstanding astronomers of the XVIII—XX centuries. These portraits are of great artistic value. Most of them are originals, including those of O. W. Struve and A. N. Savich, which were painted by the famous Russian portraitist I. N. Kramskoi, or copies of the works of the best masters. Here there is also a photographic exhibition devoted to the history and scientific work of the observatory.

The southern wing of the central part of the building is occupied by a reading-room. Before reconstruction this wing was partly made of wood and housed the transit instrument (mentioned above) in the first vertical.

The central «circular» hall is directly connected with the eastern and western halls where meridian observations are made. These two halls lead to massive brick structures which in turn are joined by heated corridors with the eastern and western wings of the main building.

Laboratories and administrative units are situated in both these wings. In the western wing there is a red marble conference hall with bas-reliefs of oustanding Russian and foreign astronomers. Outside in two niches of the northern facade of the building are statues of two great astronomers, Copernicus and Galilei.

The «scientific site» with observation towers and pavilions is situated to the south of the main building. Behind it is the building of the depaartment of radio astronomy and radio telescopes. The largest of the latter is spread



New large zenith-telescope.

like a fan and is 120 meters in length, measured along its chord.

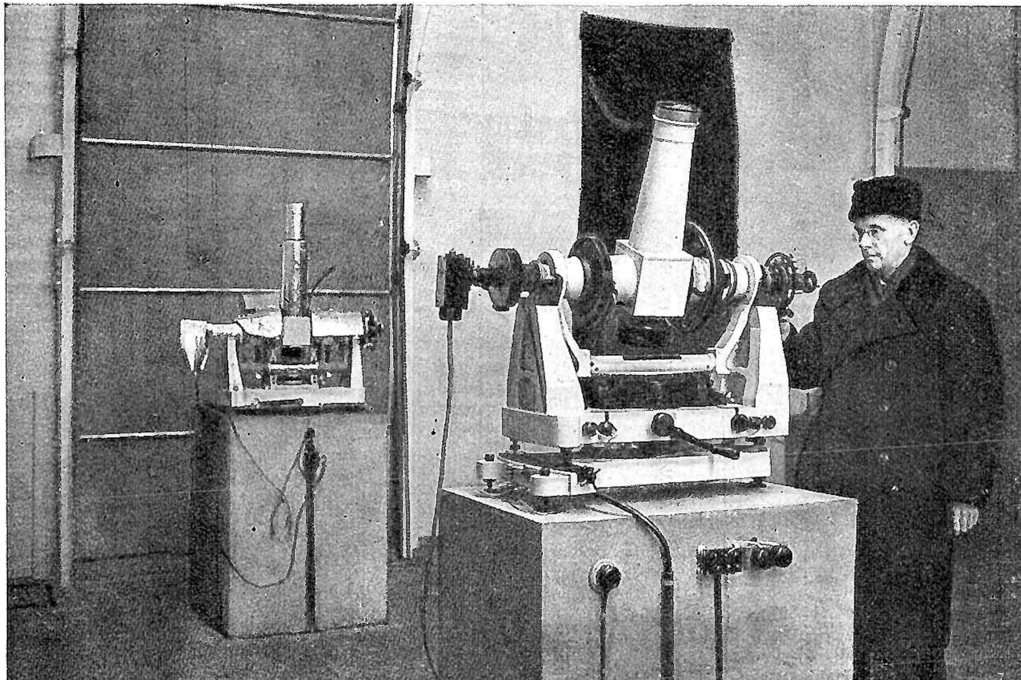
On the sloping eastern part of the hill, along the Kiev highway, living quarters and auxiliary buildings are located. These occupy the south-eastern part of the territory. The observatory has well-equipped mechanical and optical workshops where the instruments are repaired and various unique instruments, including telescopes, made.

The territory of the observatory from the side of the Kiev highway is bordered by an iron fence with a propylaeum at the central entrance, in doric style as the northern portico of the main building. From the entrance gates a two-story hotel (architect D. Yenikeev) can be seen.

At present a seperate building for the astrophysical laboratory with an optical tunnel is being completed. It is located to the west of the main building. Here is also situated the Seismic Station, now one of the stations of the Institute of Physics of the Earth, Academy of Sciences, founded by Academician Golitsin in 1906. A bust in memory of this outstanding scientist stands on a pedestal in front of the station.

When describing the Pulkovo Observatory it is necessary to mention the cemeteries on its territories. In the astronomical cemetery the graves of F. W. Struve and his wife, O. A. Backlund, A. A. Belopolsky, S. K. Kostinsky and many former members of the staff can be found. During the Great Patriotic War the defenders of the Pulkovo heights were buried on the northern slope in a common grave before the main building on the Pulkovo meridian. The latter is marked by a memorial stone. In the future in its place an obelisk will be erected in memory of the heroes who fell in battle defending Leningrad.

After the war the observatory acquired a considerable number of new instruments. These, together with the old instruments which it had been possible to save, are mount-



Time Service transit instruments with photoelectrical registration.

ed in domes and pavilions of the main building and the scientific site. Of the old instruments mentioned above the following are in use at present: the large transit instrument, the vertical circle, the Freiberg-Kondratyev zenith telescope and the normal astrograph. The Repsold meridian circle has been moved to Nicolayev. In its place a more modern Töpfer meridian circle ($D=190$ mm, $f=250$ cm) is installed. Pulkovo has a Zeiss refractor ($D=650$ mm, $f=1050$ cm), the largest in the USSR.

In 1951 observations with the restored Ponomarev—Maksutov horizontal solar telescope were begun. That same year a Maksutov meniscus telescope ($D=500$ mm, $f=650$ cm), made in Leningrad, was mounted. Various problems are solved with the help of small original instruments: the Ponomarev double short-focus astrograph ($D=100$ mm, $f=70$ cm), the Slussarev mirror-lens camera ($D=280$ mm, $f=150$ cm), a reflecting telescope with a non-slit quartz spectrograph of the Melnikov—Ionissiani system ($D=250$ mm, $f=75$ cm), a non-slit meniscus diffracting prism spectrograph designed by Maksutov and Ionissiani, the Linnik stellar interferometer and the Linnik interferometric heliometer.

All these instruments were made by the Soviet optical-mechanical industry during the post-war years. Besides, the following were made at the mechanical and optical shops of the observatory: the polar tube of the Mikhailov system ($D=200$ m, $f=600$ cm), the Sukharev horizontal meridian instrument ($D=115$ mm, $f=160$ cm, the diameter of the plane mirror — 180 mm) and a reflector on an azimuthal mounting (parabolic mirror $D=250$ mm, $f=102$ cm). These are all installed at the observatory.

Two more instruments, made in Leningrad, were acquired for the International Geophysical Year: a zenith telescope (D=180 mm, f=235 cm) and a photographic zenith tube ($D=250$ mm, $f=400$ cm).

An important event in the life of the observatory was the construction of a radio telescope, the largest in the USSR, which operates in the centimeter diapason with a maximum revolving power (up to 1′ in the horizontal direction and about 1° in the vertical direction).

At present the observatory has eight scientific departments:

1) Fundamental astrometry,

2) Astronomical constants and the motion of the Earth's pole,

3) Time Service,

4) Photographic astrometry and stellar astronomy

5) Stellar physics,

6) Solar physics,

7) Radio astronomy,

8) Construction of astronomical instruments.

The Astrometrical Laboratory and the Computing Station, which serve all the astrometrical departments (the first four), are a part of the department of fundamental astrometry. The work of the station for observing sputniks is connected with the department of photographic astrometry and stellar astronomy. The department of radio astronomy includes a group of scientists who study planets. The expedition group for studying astroclimate is supervised by the department for the construction of astrometrical instruments.

The observatory is headed by the director, elected every three years according to the Statutes of the Academy of Sciences of the USSR by the general meeting of the Physical-Mathematical Division. Since 1947 the post of director has been occupied by the corresponding-member of the Academy, A. A. Mikhailov.

The Scientific Council of the observatory is a consultative body which discusses the plans for scientific investigations, scientific papers and information, problems dealing with the preparation of scientific personnel, elects the heads of the departments and the senior scientific-workers and confers scientific degrees of candidate or doctor of physical-mathematical sciences.

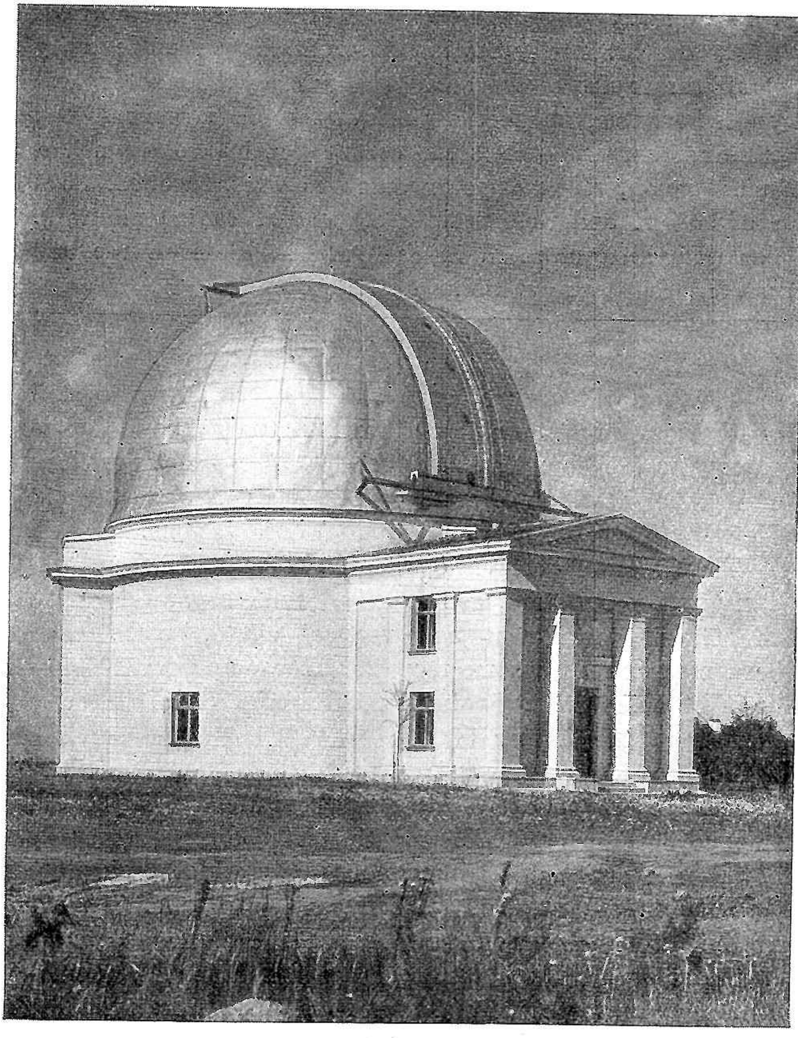
The Central Astronomical Observatory is a part of the Physical-Mathematical Division of the Academy of Sciences of the USSR. Its work is coordinated with that of other astronomical institutions through the Astronomical Council of the Academy.

The observatory has two branches: the Nikolayev Observatory (in Nikolayev, the Ukraine) and a Mountain Station (near Kislovodsk, Northern Caucasus).

The organization of a southern branch (first in Odessa and then Nikolayév) had as its aim the extension of meridian observations made at Pulkovo to the southern sky. The work of the Nikolayev branch essentially supplements that of the Pulkovo Observatory of the compilation of catalogues. Besides, the Nikolayev Observatory has a well-equipped Time Service which is one of the twelve Soviet Time Services of high precision.

The following are the main instruments of the Nikolayev Observatory: the Freiberg transit instrument ($D=108$ mm, $f=130$ cm), a Repsold vertical circle ($D=108$ mm, $f=140$ cm) and a Repsold meridian circle (moved from Pulkovo in 1954). This branch is headed by a Pulkovo asrtonomer, J. E. Gordon.

The Mountain Station at a height of 2130 meters above sea-level and 26 kilometers from Kislovodsk was organized by M. N. Gnevishev for observations of the solar corona with a non-eclipse Lyot coronograph ($D=200$ mm, $f=300$ cm). Various systematic solar observations supplement the observations of the corona. These are made with the instruments of the station: a meniscus heliograph of the Maksutov system ($D=100$ mm, $f=880$ cm), a diffraction spectrograph with auxiliary optical parts (coelostat $D=300$ mm,



Dome of the 26-inch refractor.

spherical mirror $D=250$ mm, $f=1200$ cm), a chromospheric telescope ($D=60$ mm, $f=215$ and 535 cm) and a radio telescope-interferometer operating on 1.7 meters.

At the Mountain Station observations are made daily of all the layers of the solar atmosphere: the photosphere (spots, faculae, magnetic fields), the chromosphere and prominences, and the solar corona (optical observations in the green, red and yellow coronal lines, $\lambda\lambda$ 5303, 6374 and 5694 Å and observations of coronal radio emission). The data are published in the bulletin «Solar Data» and in «The Catologue of Solar Activity».

SCIENTIFIC WORK

The traditional problem, which up till now is still of foremost importance in the work of the Pulkovo Observatory, is the compilation of catalogues of exact positions and proper motions of stars on the basis of absolute and differential (including photographic) observations.

The absolute observations of right ascensions and declinations of stars are, as formerly, made separately with the transit instrument and vertical circle, which have been modernized in some respects. However now the program of observations includes 1000 bright and faint stars instead of the former 500.

The meridian observations are made on an especially large scale in connection with the compilation of the Catalogue of Faint Stars. After the IX General Assembly of the International Astronomical Union, which took place in Dublin in 1955, this work merged into a large international undertaking on the reobservation of reference stars of the so-called Zonal Photographic Catalogues. The coordinates of more than 30 000 reference stars from meridian observations are being determined at 12 observatories of the world (Washington, Greenwich, Paris, Heidelberg, etc.), including the Pulkovo and Nikolayev Observatories.

Observations according to the program of the Catalogue of Faint Stars made during the post-war years at eight Soviet and two foreign observatories (Bucharest and Wročlaw) served as a basis for «The Preliminary General Catalogue of Fundamental Faint Stars» compiled at Pulkovo by M. S. Zverev and D. D. Polozentsev.

As a result of the analyses of a one hundred year series of absolute observations with the large transit instrument A. A. Nemiro compiled «The Pulkovo Catalogue of Right Ascensions of Stars».

The program of photographic observations for the determination of the proper motions of stars relative to the galaxies, drawn-up by the Pulkovo astronomers, is now adopted by several Soviet and foreign observatories. In 1955 A. N. Deutsch, V. V. Lavdovsky and N. V. Fatchikhin published «The Catalogue of 1508 Galaxies» which contained data on galaxies in 157 selected areas and an estimation on the suitability of the photographic image of each galaxy for photographic measurements. Now a program for observations in other regions of the sky with galaxies is being worked-out. The photographs of areas of the sky with galaxies taken with the normal astrograph supply the data for the first epochs and will be of great importance for fundamental catalogues in the future.

At Pulkovo much attention is paid to another traditional problem — the determination of astronomical constants — values which characterize the motion of the Earth and the position of its axis in space (precession and nutation) and also connected with the velocity of light (annual and diurnal aberration). In order to derive more precise values of the constants of nutation and aberration A. A. Mikhailov proposed the design of a fixed photographic tube which systematically registers the position of the celestial pole by photographing the polar region of the sky. Such a polar tube was made in rebuilt Pulkovo.

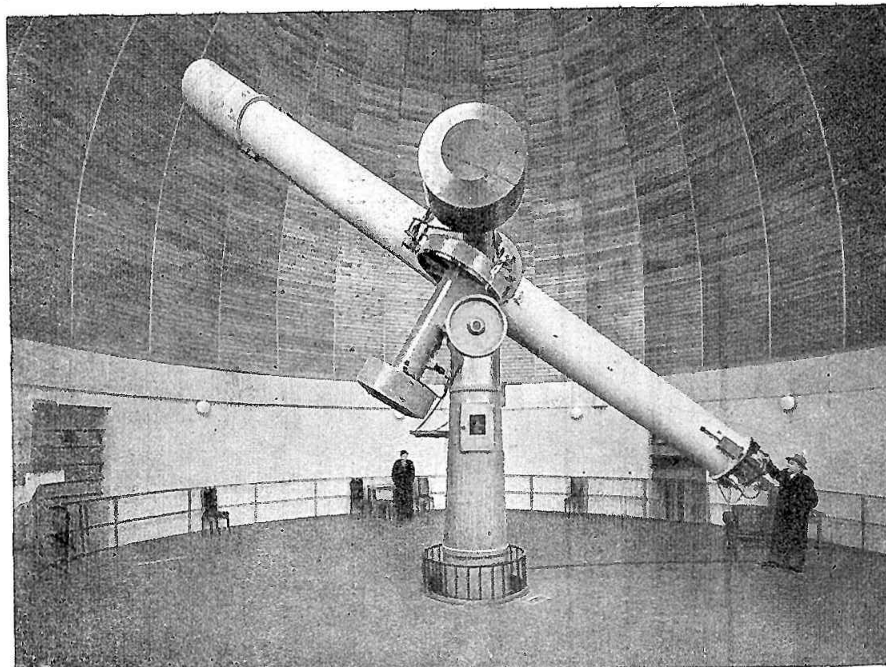
H. I. Potter, who has worked in this field since 1953, has essentially perfected the method of observations and reduction.

An important role in increasing the precision of astronomical and geodetical observations is played by systematic latitude determinations (Latitude Service), which furnish data on the motion of the pole connected with cyclic variations of the moment of inertia of the Earth. The Pulkovo Latitude Service, the first to resume observations during the period of rebuilding of the observatory, derives results of high precision which are used by the Soviet Service of the Coordinates of the Earth's pole and are regularly sent to the Central Bureau of the International Latitude Service (Turin, Italy) and the International Bureau de l'Heure in Paris.

In June 1957 for the International Geophysical Year a second zenith telescope was mounted for studying the influence of instrumental errors on the results of latitude observations and for increasing the precision of the latter. The idea of observing simultaneously with two zenith telescopes was proposed by Pulkovo astronomers and applied for the first time. It was also adopted by several observatories which carry-on latitude work (Poltava, Kazan, Kitab).

The recently mounted new instrument, the photographic zenith tube, simultaneously deals with two problems — Latitude Service and Time Service — and should essentially increase the precision of observations of astronomical clock corrections and latitude variations.

The Time Service comprises three elements: the determination of time from astronomical observations, the keeping of time with clocks of high-accuracy and the transmission of signals of exact time by radio. According to the accuracy of observations the Pulkovo Time Service occupies one of the first places in the world. In this respect the photoelectric method of registration of



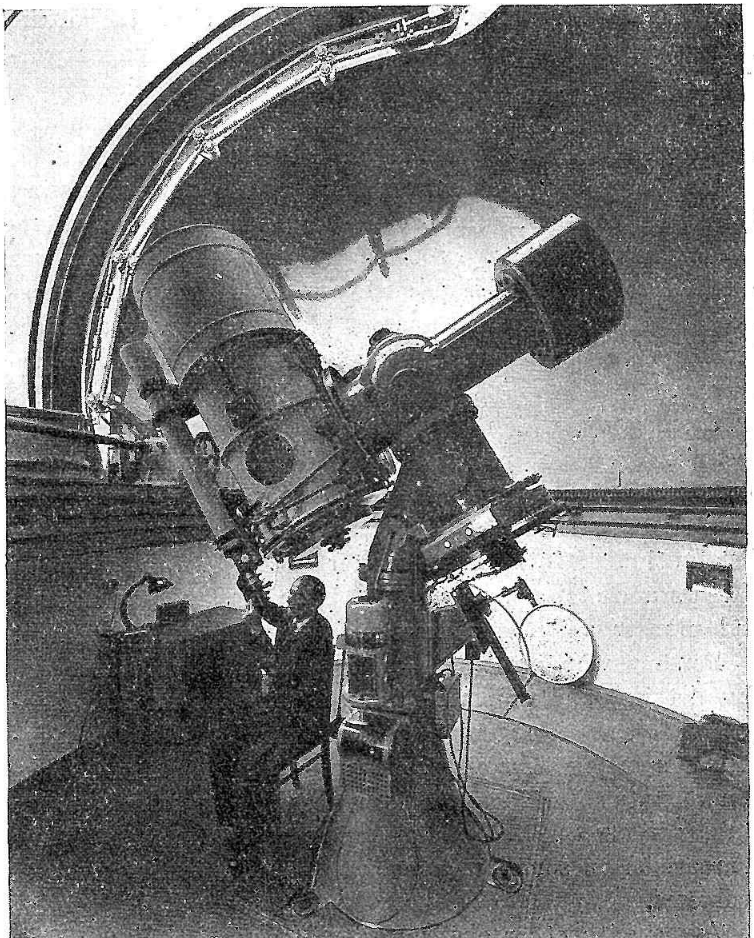
26-inch refracting telescope.

star transits proposed by N. N. Pavlov was of great importance as it excludes the personal error of the observer. Pavlov's method received wide application and the various perfections of the method enable the derivation of results of ever increasing precision.

Observations made during many years with the photoelectric (self-registering) transit instrument permitted the elucidation of the influence of instrumental errors, especially those of thermal origin. The investigation of the thermal condition of transit instruments and its influence on the results of astronomical observations, made by V. M. Vasilyev, showed the necessity of taking into account the errors, arising from temperature inequalities of the instrument and surrounding air, and of their more detailed study during astronomical observations.

Recently N. N. Pavlov designed a new transit instrument, the application of which should further the increase of precision of Time Service observations. For improving the conditions for keeping time four quartz clocks are kept in a boring, 40 meters deep. At present the transmission of time is not a task of the observatory, although the initiative in this field belongs to it.

With the launching of the sputniks new problems arose in astrometry. These received immediate attention at Pulkovo. For astronomers the sputniks represent fast-moving celestial bodies whose position (coordinates and time) it is necessary to determine with high precision in order to compute the orbit of the sputnik and solve a series of geophysical and geodetical problems. At the observatory a station has been organized for visual observations of the sputniks. This station has 30 standard telescopes ($D=50$ mm, magnification 6×, field angle 11°). The observations of the sputniks are made daily by a group of voluntary observers. Photographic observations were begun with the launching of the first sputnik. These have an advantage over



Maksutov meniscus telescope.

visual observations as the position of the sputnik and the time can be registered with a higher accuracy. Improvements in the methods of photographic observations have been proposed by many scientific workers of the observatory, most of them have been realized. The paper published by A. A. Mikhailov in 1957 on the Application of Observations of the Moon for Geodetical Purposes can also be used for the same problems relative to the sputniks.

The large scope of astrometrical work made necessary the application of mechanization in the reduction of astronomical observations. In 1956 a Computing Station was founded at Pulkovo. Here such various mechanical operations as calculating the apparent places of stars, statistical investigations of processes of solar activity, etc. are performed.

Cosmogony, which is of great philosophical importance, occupies a special place in modern astronomy. This problem deals with many sides of stellar astronomy and astrophysics: the structure and dynamics of stellar systems, the distribution of interstellar matter in space, the evolution of stars and stellar systems, the internal structure of stars and planets and the sources of solar and stellar energy.

Persons who are not directly connected with all the fine details of astronomical investigations, sometimes suppose that the cosmogonical problem can be solved as a result of someone discovery. However in this intricate problem of natural sciences it is necessary at present to go mainly along the path of gathering scientific facts. Their comparison in some cases leads to the solution of separate problems.

Along with other observatories of our country the Pulkovo Observatory has made modest contributions to cosmogony during the post-war years. The photographs taken by S. K. Kostinsky 40—60 years ago are of great value for studying the kinematics and dynamics of stellar systems.

The photographs of the second epochs, taken during recent years, and their measurement together with those taken by Kostinsky made possible the determination of proper motions of about 25 000 stars in open stellar clusters and associations, the cosmogonical significance of which was proved by Ambartsumian at Burakan, Armenia.

Systematic investigations of spectrophotometric gradients of stars of various spectral types are made by the department of stellar physics, headed by O. A. Melnikov. As a result of the study of continuous spectra of stars and their comparison with spectra of laboratory sources of light and the Sun, a more precise value of the zero-point of the scale of stellar temperatures was derived (the spectrophotometric temperature of A0 stars was found to be close to 16 000°. Former measurements made at Potsdam and Greenwich gave 9000 and 18 000° respectively).

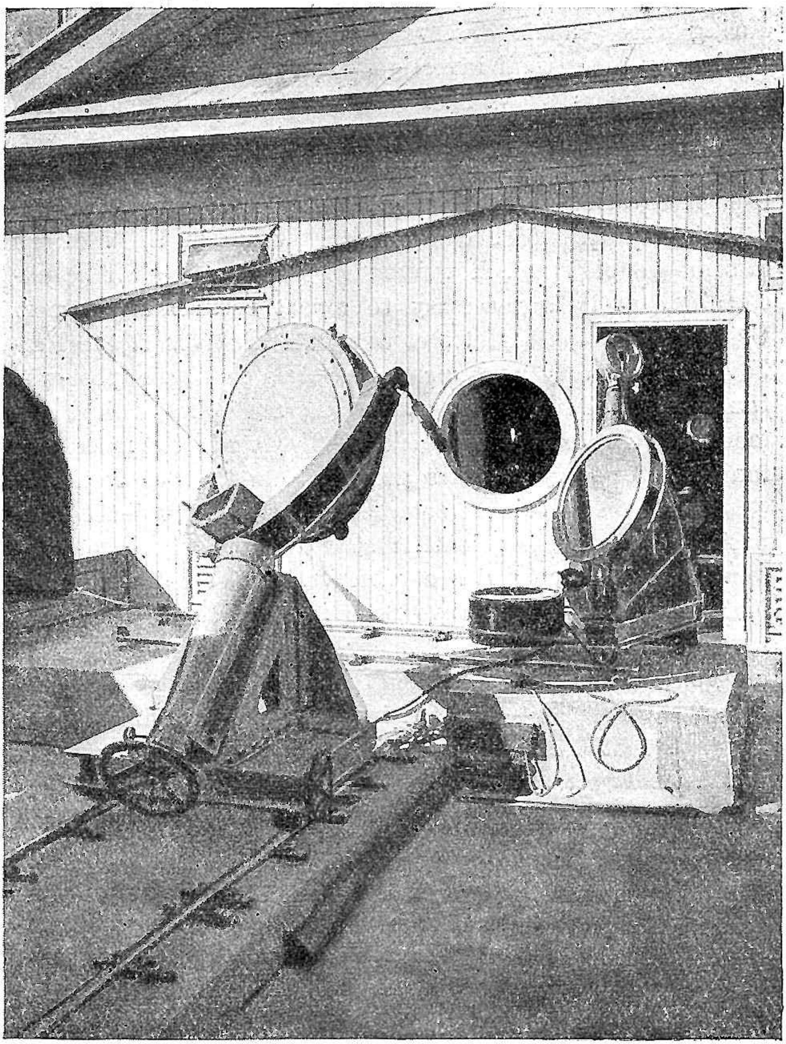
In 1944 O. A. Melnikov completed a large investigation on the spectrophotometry of Cepheids (a full account of this work was published in 1950). During this investigation the total and selective interstellar absorption was found and the problem of the zero-point of the period — luminosity curve studied, the latter being of fundamental importance for the determination of the scale of the Universe. He obtained an unexpected, at that time, result which spoke in favour of an increase of the already known distances of galaxies. Later Baade found that these distances should be increased two times. At present O. A. Melnikov, using new data on interstellar light absorption, Cepheids and different types of stellar population in the Galaxy, has confirmed his previous results.

The Pulkovo astrophysicists are keeping up the traditions of their predecessors, Hasselberg and Belopolsky, by combining astronomical observations with laboratory experiments. This is demonstrated, for example, by such a complicated experiment as the imitation of interstellar absorption. When the astrophysical laboratory, now under construction, is completed it will enable a wide range of astrophysical experiments to be made. It will have a one hundred meters long optical tunnel where gases can be compressed or rarified along a great length, resembling to some extent conditions of planetary and stellar atmospheres.

Another characteristic feature of the Pulkovo investigators is the continuous perfection of methods and instruments for astronomical observations. So in 1948 A. A. Kalinyak (together with V. B. Nikonov and V. I. Krassovsky) using electronic-optical converters detected the nucleus of the Galaxy on photographs taken in the infra-red (wave length one micron). In 1954 during the solar eclipse he phographed the solar corona in the infra-red and in 1956, using the same method, observed the great opposition of Mars.

N. F. Kuprevich with the help of photomultipliers, an amplifying scheme and oscillographs, developed a method for the automatic registration of solar and stellar spectra on films which permits their direct measurement without the complicated photographic reduction necessary when applying the usual photographic method. The registration of the solar spectrum has been shortened to record time: almost the whole visible region from $\lambda 3900°$ to $\lambda 5700$ Å is recorded during 3.5 minutes. The method of automatic registration was found to be of advantage for work in atmospheric optics, for studying the scintillation of the stars and turbulences in the Earth's atmosphere.

At present N. F. Kuprevich is working on the application of television technique in astronomy. The television-telescope constructed by him permits an increase in the brightness of the image without increasing the diameter of the entrance pupil of the telescope. In this way he was able to increase the brightness of the lunar image 300 times (for a diameter of the lunar disk on the television screen of one meter) and decrease correspondingly the ex-



Coelostat of the horizontal solar telescope.

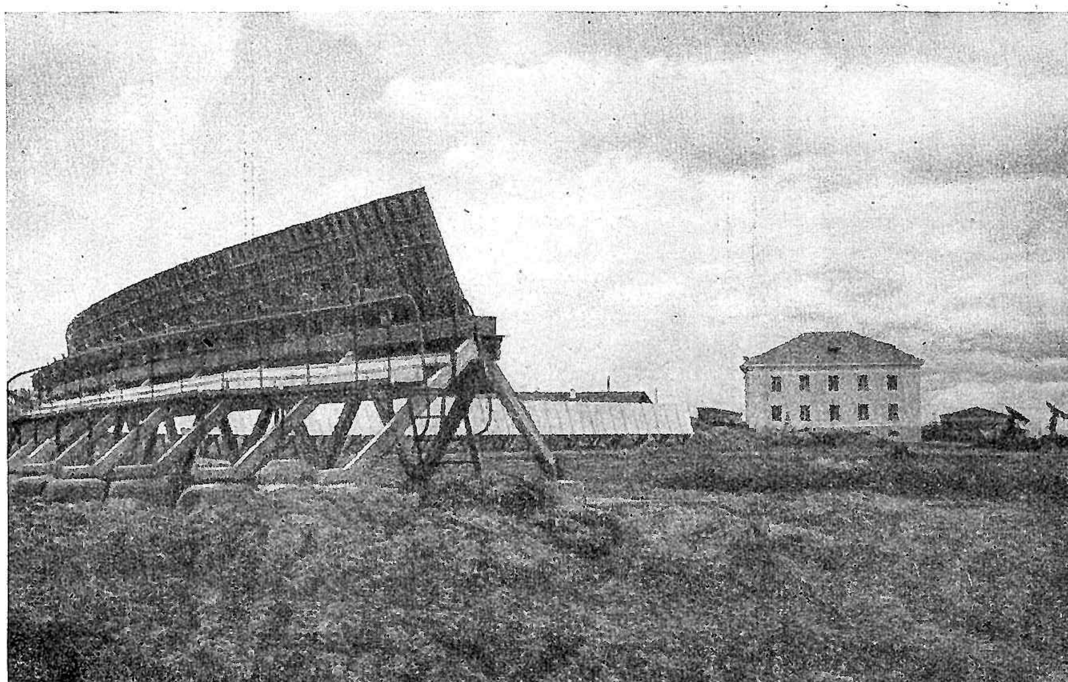
posure time for photography. He thereby showed that it is principally possible to exclude atmospheric disturbances during photographic observations of planets.

Among theoretical investigations in cosmogony a whole series of papers by V. A. Krat should be mentioned: «The Evolution of Stars», «The Origin of the Solar System» etc.

That other planetary systems exist is proved by indirect observations of dark companions of stars — invisible celestial bodies which cause perturbations in the motions of some double stars. However such observations are so uncertain that it is necessary to repeat them many times. Using photographic plates of the plate archives of the Pulkovo Observatory and also those taken in the post-war times, A. N. Deutsch determined the mass and orbital elements of the dark companion of 61 Cygni. Its mass was found to be only 8 times greater than that of Jupiter.

Solar physics and the solar service have occupied a firm position among the scientific studies of the Pulkovo Observatory. A large series of observations of solar granules and the chromosphere have been made with the Ponomarev—Maksutov horizontal solar telescope. Photographs of granulations have enabled the visible size of the granules to be found — 350 km in diameter (two times smaller than that derived by Hansky). Evidently, as supposed by V. A. Krat, there are still smaller granules, their observed size depending only on the resolving power of the instrument used.

Interferometric polarization light filters with a transmission-band of 0.5 A in H_α and H_β are used for chromospheric observations. A detailed study of the photographs of the chromosphere proves that the chromosphere is not a continuous gaseous envelope of the Sun, but has a filamentary structure. Thereby the hypothesis proposed by the Pulkovo astronomer, E. Y. Perepelkin, that the chromosphere is composed of separate small prominences is confirmed.



The large radio telescope.

On this basis V. A. Krat and V. M. Sobolev made an attempt to construct a theory of a heterogeneous chromosphere. Rejecting the accepted conceptions of the chromosphere, characterized by mean values of the physical parameters, they assumed that the chromosphere consists of groups of filaments: metallic, hydrogen, helium and subcoronal (in accordance with the conditions of emission of the spectral lines of metals, hydrogen, helium and ionized helium) and calculated the temperatures and densities and also the distribution of each group of filaments with height.

On the basis of observations with a prismatic camera of the 1941, 1945 and 1952 total solar eclipses, V. P. Vyazanitsyn proceeding from the classical theory made a detailed study of the chromosphere.

At the beginning of the International Geophysical Year the work-shops of the observatory completed a spectrograph of high resolving-power for registering the magnetic fields of sunspots and a device for the automatic registration of weak magnetic fields on the Sun.

Solar observations according to the IGY program are made mainly at the Mountain Station near Kislovodsk. This station is one of the two centers on coronal research operating in Europe during the IGY. Since 1956 the solar corona has been observed regularly at Pulkovo, nearly at sea-level, with a coronal spectrograph designed by I. A. Prokofyeva.

Along with the Solar Service the Pulkovo Observatory systematically predicts solar activity on the basis of a statistical method which is constantly being perfected. Besides B. M. Rubashev is working-out a numerical method of prediction. An important place in the elaboration of the theory of solar activity is given to the modelling of solar motions — an experimental reproduction of magnetohydrodynamic solar phenomena. The investigation of solar processes is closely connected with the problem «Sun —

Earth». Some success has been reached in the study of the mechanism connecting the active processes on the Sun with phenomena in the troposhpere (the weather and climate).

The department of radio astronomy, organized at Pulkovo in 1954, is now the largest scientific department of the observatory. It is equipped with modern apparatus, including a radio telescope of high resolving-power, constructed according to the design of S. E. Khaikin and N. L. Kaidanovsky.

The reflector of the large radio telescope consits of 90 separate plane shields, forming a zone cut out of a paraboloid. The length of the reflector, measured along the chord, is 120 meters. Observations are made in the meridian. As the celestial bodies cross the meridian at different heights the form of the surface of the reflector must previously be changed by a corresponding arrangement of the reflecting shields. The focus of the paraboloid also changes, remaining on a horizontal line which lies in the plane of the meridian. The dipole in the focus is connected by a cable with radio reception apparatus located in a separate building.

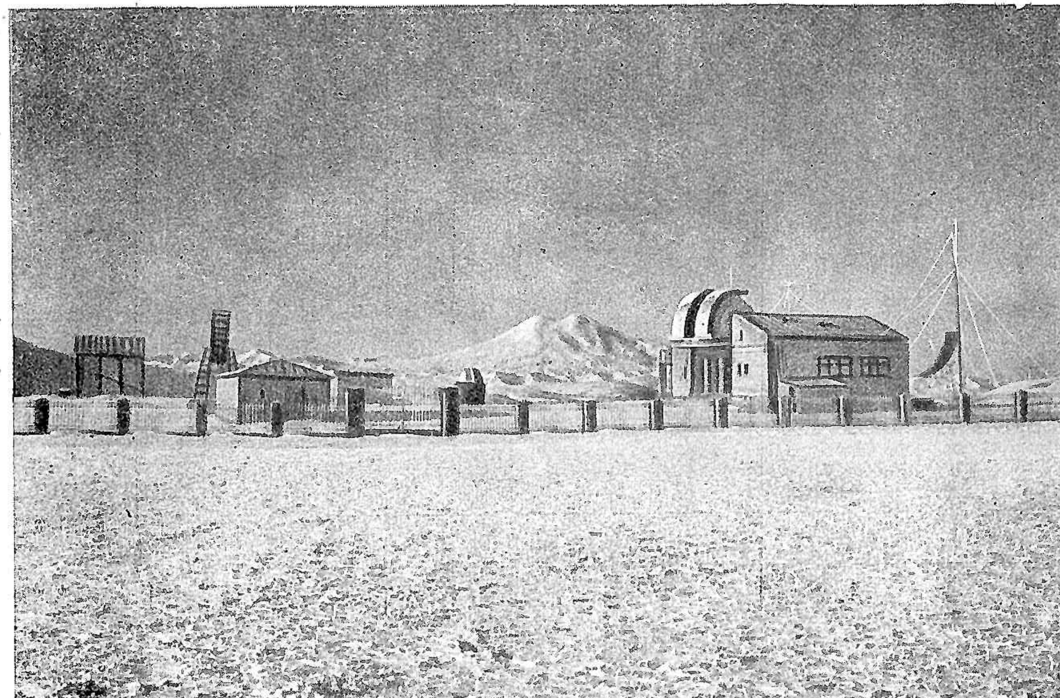
The high resolving-power of the radio telescope permits observations to be made of the intensity of radio emission across the solar disk or the Moon and also the study of the structure of local sources of radio emission in the Galaxy («radio nebulae»). Observations of the Sun and separate phenomena in its photosphere (in particular chromospheric flares), which are made in cojunction with optical observations on the horizontal solar telescope, will furnish new data for the study of solar structure and the nature of active processes.

Systematic observations of the effective center of radio emission of the Sun and the polarization of its radio emission in the centimeter diapason (both these problems are part of the observational program of the IGY) are made with radio telescopes of moderate size. D. V. Korolkov detected a strong circular polarization of the radio emission of sunspots on 3.2 meters. For the first time, during observations of the annular solar eclipse of April 19, 1958 (an expedition to south-eastern China), «spectral» polarization observations of the solar outer layers were made with four radio telescopes operating on 2, 3, 5, and 10 cm. After the eclipse these telescopes will be mounted at Pulkovo. A method for the radio spectroscopy of the atmosphere of major planets on 1.25—1.35 cm is being worked-out.

The department of the construction of astronomical instruments is also a young, rapidly developing branch of the observatory. It was organized in 1952 and is headed by the well-known Soviet optician D. D. Maksutov. Already in the course of the past five years this new department has completed a number of important investigations dealing with the construction of first-class telescopes.

One of the first and significant works of the department was the computation of a meniscus telescope for observing planets by N. V. Merman, under the supervision of D. D. Maksutov. The diameter of the projected telescope is 700 mm, the length — 3.5 m. The theoretical resolving power is 0ʺ.2 (an amount comparable to atmospheric turbulence) and will permit the telescope to be used with advantage for photographing the Moon and bright planets with focal ratios 1 : 14, 1 : 20, 1 : 28 and exposure less than 0.1 second, without using supersensitive photographic materials which have a small resolving power. The telescope was computed according to an order from the Planetary Commission of the Astronomical Council and is now in construction.

The following were computed and designed by the department of the Construction of Astronomical Instruments and made at the work-shops of the observatory: a reflector with a parabolic mirror ($D=250$ mm), a dual-



Solar station in the Caucasus, altitude 2130 m.

rate camera for photographing the Moon by the Markowitz method, a reflecting telescope for investigating the most advantageous costruction of a tube (open, closed and ribbed) and expeditional meniscus telescopes ($D=140$ mm) for studying the astroclimate. For one of the latter a new meniscus scheme with an elliptic main mirror was used. This scheme was recently proposed by D. D. Maksutov and gives a substantial increase of the field of view.

Simultaneously the department carried on vast theoretical investigations of various classical and non-classical mirror and mirror-lens systems in order to find the most rational optical scheme for the construction of telescopes. The results of these studies were used for the 2.6 meter telescope of the Crimean Astrophysical Observatory.

The compensation method of investigating mirrors of large telescopes, elaborated by D. D. Maksutov, was used for making the mirrors of this telescope. As a result of the decrease in size of the auxiliary testing mirrors, this method according to preliminary calculations led to a decrease in the cost of making the optical parts by 2.4 times and shortens the time necessary for making the mirror by three.

The construction group of the department completed a project of a 700 mm reflecting telescope which is being made in the mechanical and optical shops of the observatory. The main parabolic mirror of the telescope is being ground from a metal block (because of the high heat-conductivity of the metal the figuring of such a mirror to a parabolic form is very complicated and requires the development of special methods). The 700 mm telescope will serve for the verification of various new principles of construction of telescopes, in particular a complete automatization of control and guiding using N. N. Michelson's electronic computer.

New astronomical instruments are also designed by the Astrometrical Laboratory of the observatory. In 1953 L. A. Sukharev completed a model of a horizontal meridian instrument ($D=115$ mm, $f=160$ cm, diameter of the mirror — 180 mm). Its advantage over the usual meridian instrument is that there is no tube flexure as the usual rotating tube is replaced by a combination of a plane rotating mirror and two non-movable horizontal tubes. The experimental observations with the model of the instrument proved the expediency of such a construction. Now a large-sized horizontal meridian telescope ($D=190$ mm, $f=420$ cm, diameter of the mirror — 300 mm) is being made at an optical shop.

The astronomical laboratory has the task of designing on a modern technical basis a large transit instrument and vertical circle which will replace the main equipment of the observatory for absolute measurements of coordinates of celestial bodies.

The new problems have made essential changes in the profile of work of the observatory. Its outer appearance is also changing — now only the main building reminds one of the old Pulkovo Observatory. It is a new large scientific institution which contains the seeds of its future growth and development.

CONTENTS

Заказ № 717