THE RADIO TELESCOPE RATAN 600

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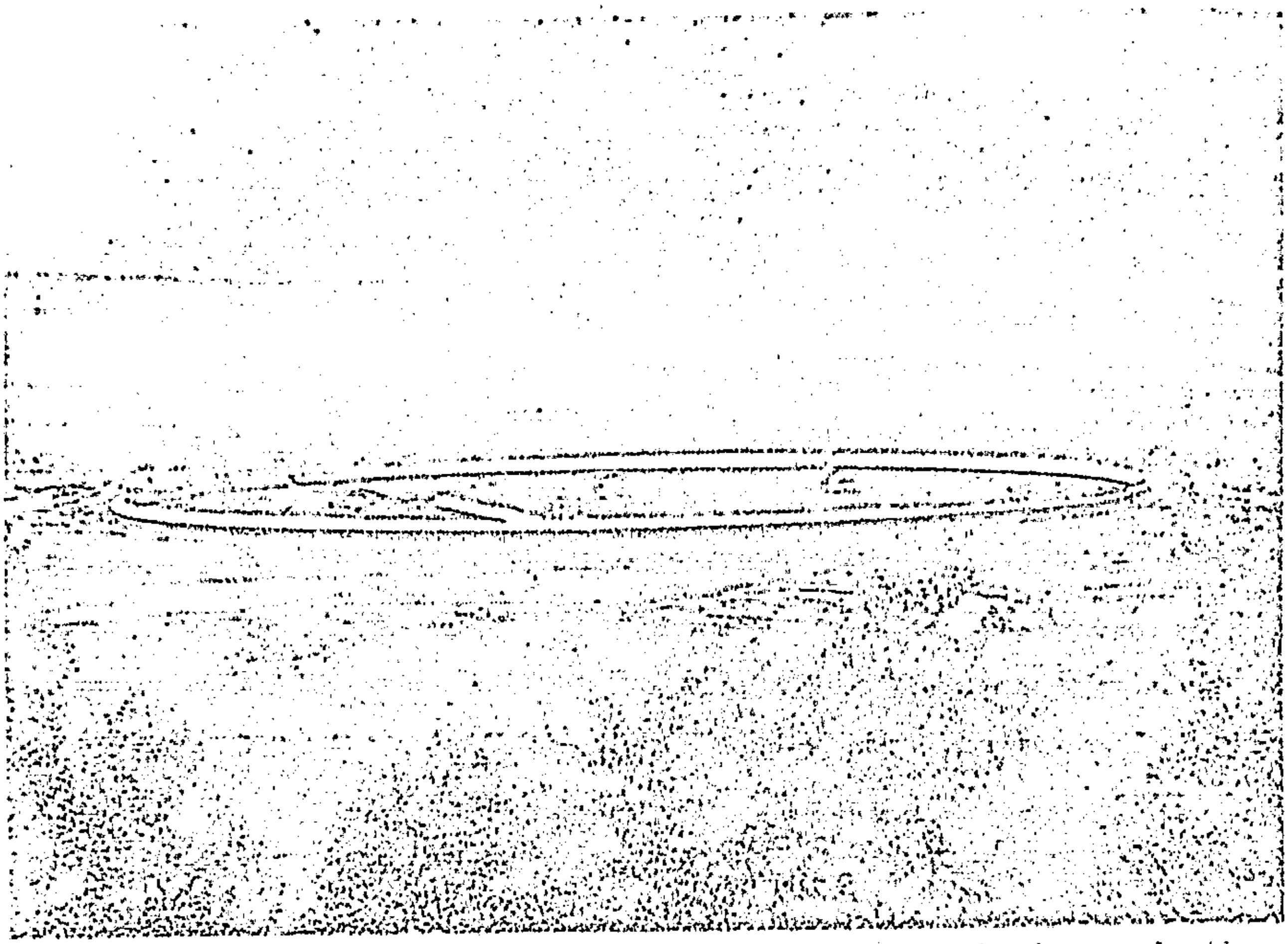
Large investments have been made in recent years for the instrumentation of Soviet astronomical institutes. These developments are of interest to us not only because of the dimension of the two most spectacular instruments — the 6 meter optical mirror and the RATAN 600 radio telescope — but also because of the increasing collaboration between Soviet and German astronomers. /242#

As a result of a workshop meeting in November 1976 in Moscow, a closer collaboration in the area of radioastronomy was agreed upon. As a consequence, a formal agreement between the Academy of Science of the USSR and the Deutsche Forshungsgemeinschaft was signed. Since then, several interferometric observations with the aid of the 22 meter telescope in Simeis on the Crimea and the 100 meter telescope in Effelsberg, and also simultaneous observations of pulsars using the Pushino Observatory and the 100 meter telescope, were carried out. Visits of Soviet astronomers to the Federal Republic came about, and German astronomers were able for the first time to use the 6 meter optical telescope for infrared observations (see Schultz, "Observations in the Soviet Union", SuW, Vol. 17, p. 201).

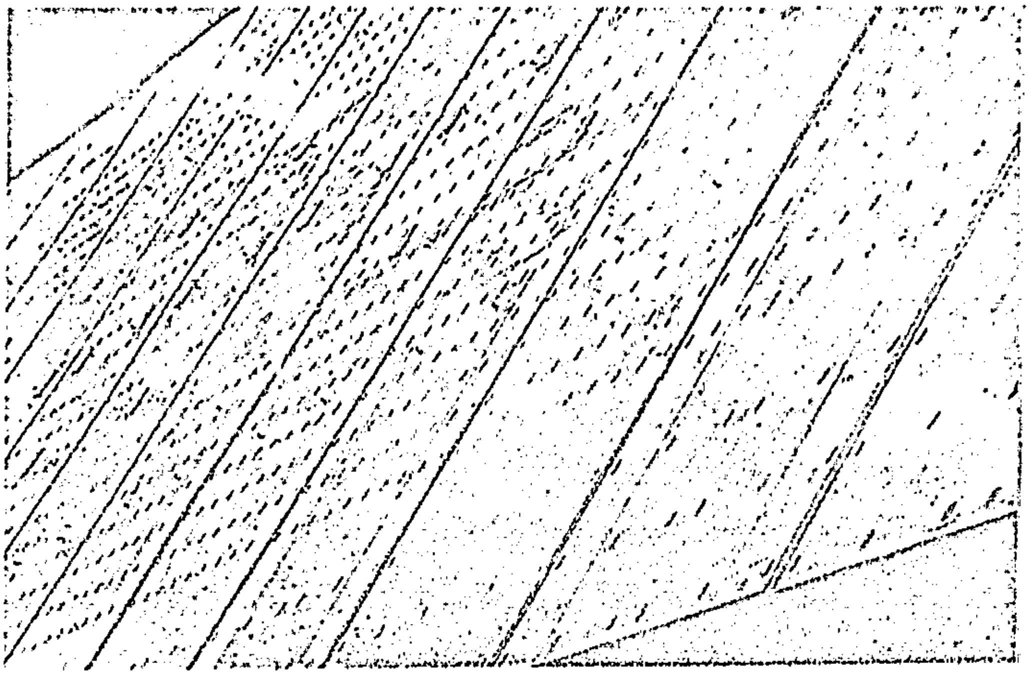
#Numbers in the margin indicate pagination in the original foreign text.



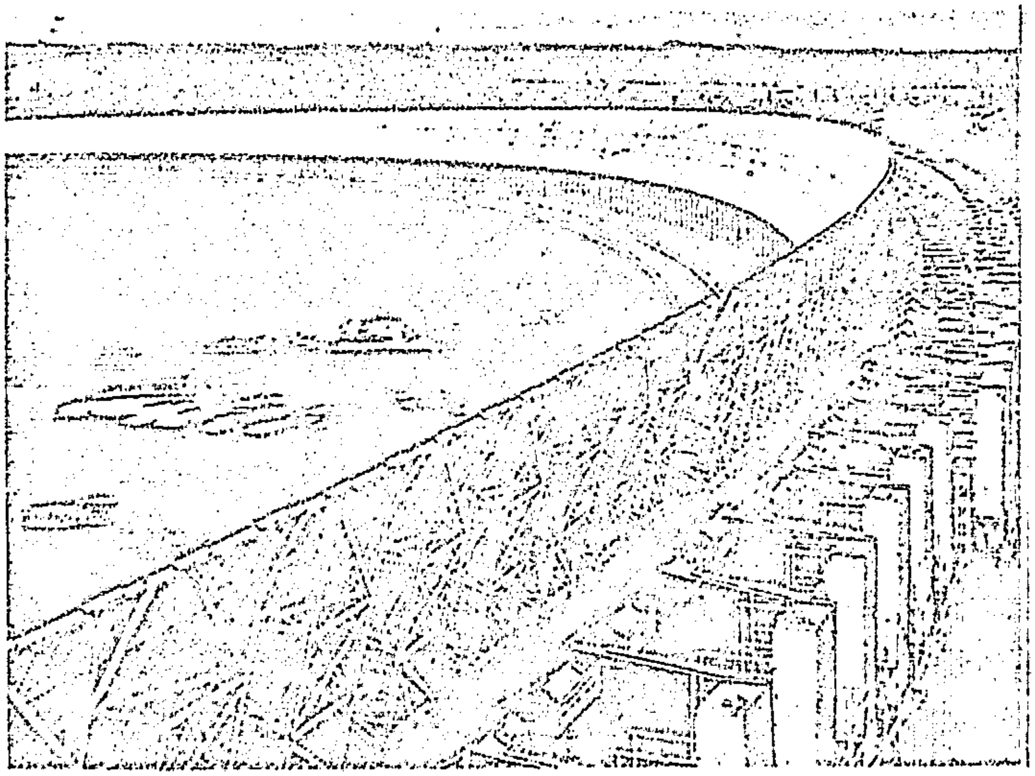
Overview of the RATAN 600 radio telescope. In the background, the North Caucasian Mountains

Following the workshop meeting mentioned above, five radio-astronomers from the Max Planck Institute for Radioastronomy in Bonn went on an information trip to several Soviet astronomical institutes. The highlight of this visit was a detailed study of the radio telescope RATAN 600.

If one approaches the Cossack settlement of Zelenchukskaha, about 1800 km SE of Moscow, an intriguing ring wall appears — the first impression of the radio telescope RATAN 600. The location is in the plain at the foot of a mountain ridge which is part of the northern part of the Caucasian Mountains. The locality was chosen on the basis of climatic criteria, the essential absence of interference, and the geological structure of the ground. The 6 meter telescope is only about one hour away by car, in the mountains above the RATAN location; this gives the advantage of a common computer

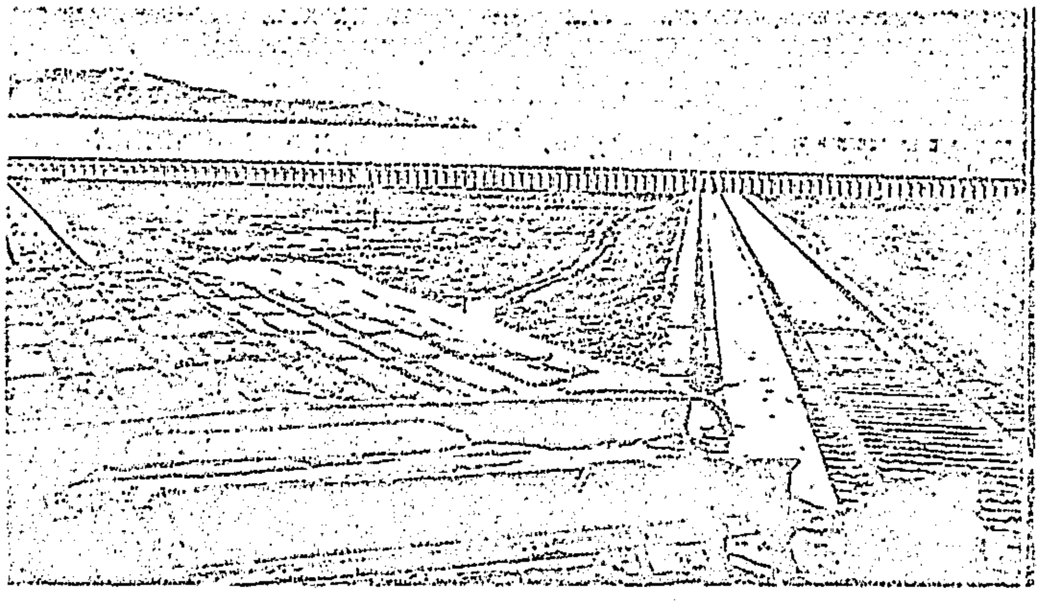


Partial view of the reflector surface which consists of 900 elements. Each of the elements with its surface area of 14 cm^2 can be adjusted with the help of 260 screws



Partial view of the reflector surface in circular arrangement. The individual elements may be rotated horizontally and vertically, and moved laterally center, a common guest house, and a common car pool. Administratively, the two telescopes belong to one institute, the SAO [Special Astronomical Institute], which is part of the Academy of Science of the USSR.

The radio telescope is an antenna with variable profile. Such antennas consist of a large number of reflector elements which are either plane or mildly curved. In the initial position, they are in a circular arrangement. For this reason, the RATAN instrument with its 900 reflector elements arranged on a circle of diameter 579 meters looks like a huge ring wall. The elements are about 7.4 m x 2 m, resulting in a total reflector surface of about 10,000 m^2. The accuracy of the elements at the time of our visit in late 1976 was about 0.4mm (rms), with the hope to achieve a final accuracy of 0.2 to* 0.3 mm after additional adjustments. The surface form of the elements is obtained by adjusting 260 screws each. Thus, improving the adjustment of the elements to reach an accuracy of 0.2 mm requires the adjustment of 240,000 screws. At that point, observations at the projected limiting wavelength of 4 mm will be possible, while at /244



Tracks are placed inside of the circular area. Subreflectors can be moved on these tracks

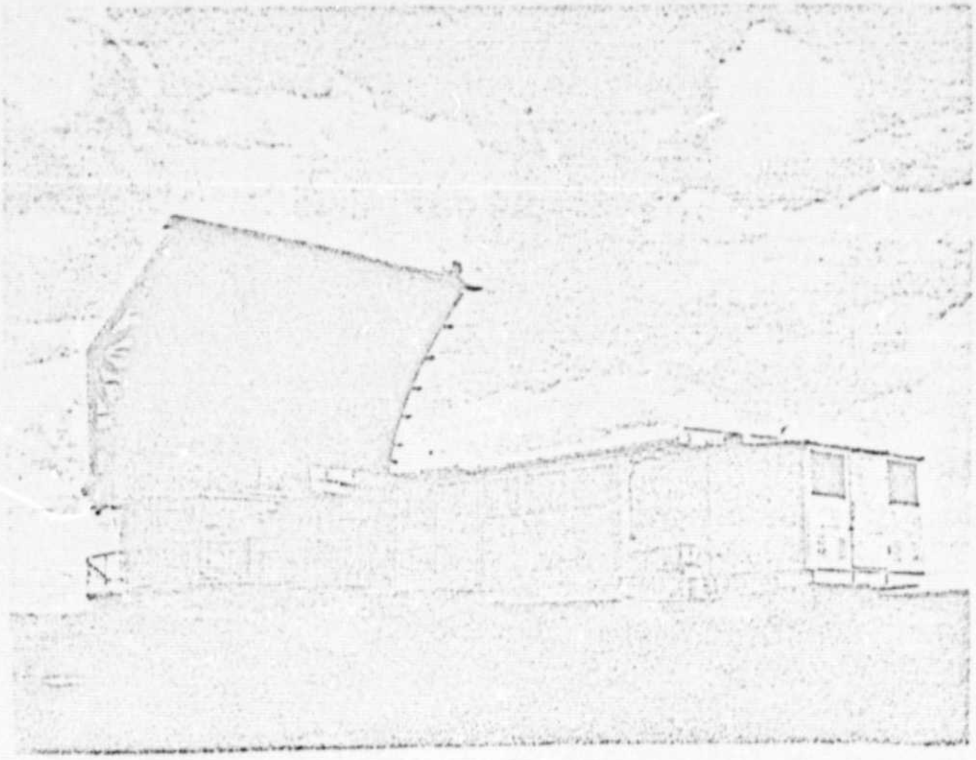
*Translator's note. Given in original text as "at".

present observations down to 8 mm are possible. The observations at 8 mm resulted in a halfwidth of the antenna beam in azimuth of 5 arcsec.

Each element of the reflector has three degrees of freedom: it may be rotated about a vertical and horizontal axis, and moved translationally in the radial direction. Initially, the adjustment of the telescope was done by computing tables for the necessary motion of the reflector elements for a given observation. A group of female operators then carried out the setting of the numerous motors. The transition to a completely computer-controlled operation had been scheduled for 1977.

The directional profile of such an antenna system is determined by the position of the reflector elements with respect to that of the subreflector in the focus of the reflector surface. By contrast to a fully steerable, for instance, parabolic antenna, a change in the direction of observation is not effected by rotating the entire reflector surface, but by changing the reflector form. That is, changing the directional profile or the observational direction is effected by shifting the subreflector and changing the position of the reflecting elements with respect to the subreflector.

In order to enable the subreflector to be movable, the circular area is equipped with a grid of tracks which look as if they were arranged in the form of a star. There are altogether four asymmetric cylindrical paraboloids serving as subreflectors. The radio telescope RATAN 600 allows for several types of observations at different elevations. First, one obtains two-dimensional information on radio sources with a resolution that is determined by the diameter of about 600 meter; however, this method of observation is only possible in the case of large elevations near 90°. Otherwise, it is necessary to carry out an aperture synthesis with repeated observations. In the range of medium elevations (40 - 60°), up to one third of the reflector elements are in operation. If the elevation angles are smaller, it is possible to use several subreflectors, each operating

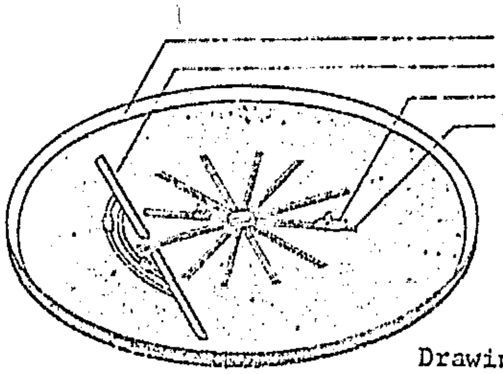


One of the cylindrical subreflectors which receive radio emission from angles up to 120° on the reflector surface. The subreflector can be moved together with the receiver station

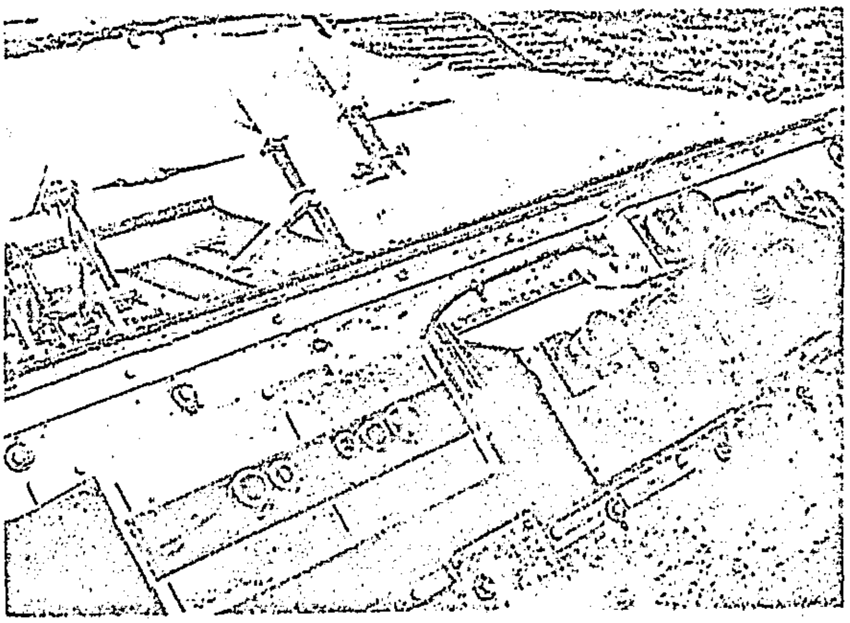
with a different sector of the reflector surface, and then carry out a parallel synthesis.

Finally, one can observe different radio sources at the same time, using different subreflectors and their associated reflector surface sectors.

All these observational methods are particularly useful in the case of continuous emission. Spectroscopic observations require larger integration times, that is, the telescope must follow for longer times the source to be observed. With the aid of the normal /245 subreflectors, integration times of only a few minutes are possible. It is planned for this reason to make use of a subreflector that can move on a circle, when spectroscopic observations are required. This subreflector receives reflected radiation from a plane surface built linearly inside of the circular setup. This type of obser-



Drawing of the entire installation



It is possible to arrange along the focal line of a subreflector several horn antennas which allow for simultaneous observations at different wavelengths

vation in which the source is followed for several hours is similar to the method used with the Nancay radio telescope.

The flexibility of the RATAN setup is even more obvious if one recalls that it allows with each subreflector for simultaneous observations at various wavelengths. In fact, it is quite simple to arrange along the focal line of a subreflector several primary antennas for different wavelengths.

Each subreflector is connected to a receiving station. During our visit, for instance, the laboratory of the first subreflector operated simultaneously receiver systems at 2, 4, 6.5 and 13 cm.

The laboratory of the second subreflector operated a spectroscopic system at 21 cm, with additional systems at 1.3, 6.5, and 18 cm in preparation. Aside from the principal disadvantage of the RATAN setup for spectroscopic observations, that is, the limited possibility to follow the source on the sky, only a 20-channel spectrometer (30 kHz resolution) was available, while a 100-channel spectrometer (each 15 kHz) was in the development stage.

At the third subreflector we came to know an additional method of using the facility. This is used in conjunction with a plane reflector surface. Here solar observations are made at the same time at six wavelengths between 2.3 and 5.2 cm. Plans exist to extend this to 15 receivers for simultaneous solar observation in the wavelength range between 8 mm and 7.5 cm.

A tour of the RATAN installation is educational in the area of geometric optics. The flexibility in the use of various observational methods is remarkable. With relatively small investment costs it was possible to build an installation with a large reflector surface area at small limiting wavelengths. It is not possible to build a reflector area of similar size for a completely movable telescope even at substantially higher costs. The reflector area which was built at relatively low cost with a high resolution requires a high degree of personnel expenditure in order to exploit all of the planned observational possibilities. An observer must realize that the viewing pattern is very different for the different elevation angles. The instrument is especially advantageous for continuum observations. Observations which require extensive tracking (for example, spectroscopy) can only be made to a limited degree.

Dr. Parijskii received the German delegation and gave us a tour. Dr. W. Altenhoff discussed various applications of the instrument.

Mrs. R. Krieger translated all of the information from Russian for us and we thank them.