The hydraulic structures of the Bratsk hydroelectric scheme (named after the 50th Great October Anniversary) include concrete and earth dams and a power station integrated with the dam, which together form a headwork 5 km long and up to 100 or 106 m high. These hydraulic structures were equipped with monitoring-measurement instrumentation (MMI) for conducting continual observations of their condition and performance. The MMI includes: (a) an elevation-monitoring network of over 1000 bench marks throughout the hydroelectric scheme, six principal reference points (in rock), 25 ground reference points (along the depression cone); (b) a piezometric network comprising 600 piezometers and 28 sites for measuring seepage discharge; (c) a system of monitoring-measuring devices in the concrete dam, consisting of optical (on the crest) and optical-wire (along the longitudinal foundation gallery) gauges for measuring horizontal displacements, four normal and 35 inverted plummetts, nearly 100 gap gauging points, and 2400 gauges.

This make-up of instruments permits observation of settlements and seepage over the whole area of the hydroelectric complex, horizontal displacements and the opening of contraction and construction joints, and the thermal regime and stressed state of the concrete dam. Concurrently, visual observations are conducted continually on the cracking of exposed concrete surfaces of the dam and other structures.

In addition to the basic system of observations listed above, several special observations are conducted: chemical analyses of seepage water and of deposits formed by piping: measurement of velocities and temperatures aimed at clarifying the features of the seepage regime; observations of the performance of the machine-hall roof beams; monitoring of the thermal regime and layer-by-layer settlement of soil, etc.

During the construction period, placement of the instruments and their reading were carried out directly by or under the supervision of the design or scientific-research organizations. The elevation-monitoring and piezometric networks, all the geodetic measurements, including the inverted plummetts, and the seepage-regime observations were organized and carried out by the Angara fieldwork team of the S. Ya. Zhuk All-Union Scientific-Research and Design-Investigation Institute of Hydrotechnical Construction (Gidroproekt). The installation of the direct plummetts, visual gap gauges and the remote-sensing instruments in the concrete dam, and their observation, were carried out by the Bratsk Hydroelectric Plant Construction Directorate (Bratskg4sstroi) under the direct supervision of the B. E. Vedeneev All-Union Scientific-Research Institute of Hydraulic Engineering (VNIIG). Observations of cracking in the blocks and exposed concrete surfaces were made by the All-Union Planning Institute for Organization of Electric Power Construction (Orgenerogostroi). The results of all the observations were presented in the form of separate reports from each of the above-mentioned organizations; in its report VNIIG gave a general analysis of the state of the structure, based on all the types of observations.

The observation (MMI) group attached to the Bratsk Hydropower Scheme directorate was formed in 1961 and incorporated in the hydrostation organization. Part of its complement (geodetic surveyor, hydraulic engineer, several observers) were transferred to Gidroproekt's Angara field team and to the Bratskg4sstroi observation group, which operated under VNIIG's supervision, for probationary purposes; the remainder carried out observations which were associated mostly with construction-stage monitoring. The Directorate received the observation results in the form of completed reports prepared by the Angara field team, Orgenerogostroi, and VNIIG. After commissioning the power plant for industrial service in 1967, all observations which had been made by the Bratskg4sstroi group, and the seepage observations by the Angara field team, were transferred to the management of the MMI group at the Bratsk hydropower scheme. This MMI group has carried out independently all the observations since 1968 ex-
cept the geodetic surveys, namely, the first-order leveling (settlement measurements of concrete dams and the power-station building) and optical ranging observations along the crest, which are being made by the Geodesy Department of the Irkutsk Polytechnic Institute.

At the commencement of its independent activities in 1968, the MMI group numbered 30 men; at the present time (1974) it comprises 23 men, including six engineering-technical staff—four engineers and two technicians. The group is led by a senior hydraulic engineer who is responsible to the manager of the hydrostation organization. The MMI group is divided into three subgroups, each handling specific tasks: concrete dams (6 men), seepage (10 men), geodetic surveys (5 men). Each subgroup is headed by senior specialists, and a geodetic surveyor. The MMI group has a workshop for repairing instruments, carried out by a Grade-V fitter.

The observations are made in accordance with annual programs which establish their scope and frequency. The annual programs are coordinated with VNIIG and approved by the Chief Engineer of the power station. The observational data are processed, analyzed, and used as a basis for information sheets, issued twice a year, containing firm conclusions regarding the state of the hydraulic structures and recommendations regarding their repair. The reports are sent to Gidroproekt, VNIIG, and the Regional Electricity Board (RÉU) of the Irkutsk Power Directorate (Irkutskenergo). There is a permanent agreement with VNIIG during the operational period. Before 1970, reports on the state of the hydropower scheme were compiled in VNIIG; at the present time the MMI group prepares the reports independently and VNIIG makes its conclusions therefrom.

Apart from making the observations, the MMI group carries out the operational servicing of the whole monitoring-measurement instrumentation system and the work involved in its repair and modernization. The larger and more labor-consuming work is carried out by specialists from other centers or departments in accordance with orders placed by the MMI group. Some of the most complex work was done by contract organizations in accordance with designs prepared by scientific institutes. Since 1968, the MMI system has been considerably modernized: the collars of all open piezometers (nearly 300) have been replaced; an optical-wire gauge has been mounted in the inspection gallery of the river portion of the dam (to a design prepared by the Scientific-Research Station of Gidroproekt); the switching system for the gauges has been revised and an automatic unit installed for reading remote MMI (to a design prepared by an under the supervision of VNIIG); and remote mechanical latches were mounted on the direct plummetts. At the present time, the heads of the inverted plummetts are being reconstructed, with a device for direct reading of coordinates; at measuring points in the drainage systems, weirs are being installed with remote sensing devices for measuring levels where access is difficult.*

During the operational period, certain difficulties arose in organizing the work of the MMI group. In practice, the full-scale observations were found to segregate themselves sharply into the construction and operating periods. The basic experience on observations and, more importantly, all of the experience in the processing and analysis of the results accumulated during the construction period, also almost all the documentation on the processing of the observations, remained in VNIIG and in the Angara field team of Gidroproekt. Remaining at the disposal of the Directorate were only the as-constructed details of the MMI installations, work diaries with the initial records of readings, and reports on the results of observations. In order to have an opportunity for independent analysis, the MMI group was obliged, on the basis of the experience gained during its probation at VNIIG (in the Bratskéústroi observations group) and in the Angara field team, to recompute and replott nearly 1000 graphs from instrument readings taken from commencement of observations. A new system of analysis had to be established, taking into account that comparability of the results of all types of observations. It should be noted that the comparability of observation results during the construction period left much to be desired. An example is the observational experience obtained from the normal plummetts which were VNIIG's responsibility and those from inverted plummetts of the Angara field team: these instruments had different axes and different reading marks, although both give identical information regarding the relative horizontal displacements of the dam sections.

The work of establishing a base for the independent analysis had to be carried out concurrently with the planned day-to-day observations. This organizational period for the MMI group is still not completed, and will continue for a long time on account of the laborious processing involved and the absence of technical means for speeding it up.

* Work on the weirs has been completed. The devices for remote measurement of head on a weir have been installed.