an individual visits MOSCOW

By Winston E. Kock

GROUP tours of Russia by United States and European scientists, involving about ten or twenty specialists in a given field, have become quite popular recently. On the other hand, it is not too difficult for an individual to gain entrance to Soviet scientific laboratories and this procedure has certain advantages. For one thing, the tour can be planned so that laboratories in more than one specialized field can be included in the visit. Also, individual tours generally do not involve arranging for reciprocal visits, a procedure usually required when group tours are set up.

I had been told that my attempts to see scientific laboratories would be successful only if I had in hand, before arrival, one or more letters from Soviet scientists. Such letters are not quickly come by. It apparently involves an appreciable amount of time on the part of the Soviet scientist to make the necessary arrangements. My correspondence to them sometimes required follow-up letters and some replies indicated only tentative plans, with confirmation to follow later. Accordingly, it was well that I had initiated my correspondence about four months in advance of my planned visit. Academicians can apparently arrange an invitation more quickly than other scientists. I enclosed, with my first correspondence, reprints of previous work if it was of possible interest to the recipient. In general, Russian scientists appear better acquainted with our work than we are with theirs.

With only three days in Russia I restricted my itinerary to the Moscow area. On the first day, at the invitation of Prof. A. M. Prokorov, I visited the Lebedev Institute of Physics. The next day I visited the new Moscow University, an imposing 32-story skyscraper several miles from the center of Moscow. On my last day, Academician V. A. Kotelnikov arranged for me to visit and address his Institute of Radio and Electronics, which is part of the Soviet Academy of Sciences and is located in the old university building in Moscow.

The Service Bureau of my hotel contacted Prof. Prokorov and arranged for a limousine and interpreter. Our interpreter expressed a desire to accompany me, but the guards at the Institute checked her pass and refused her admittance. I, instead, was ushered in without having to show any identification, without signing in, and without any badge formalities. Since Prokorov and his assistants spoke English very well, language was not a problem. He is very energetic and has a number of projects in progress at his laboratory. His work on masers is probably tops in Russia and he was invited to participate in the recent conference at Bloomingburg, N. Y., on Quantum Electronics—Resonance Phenomena. Other areas of activity include atomic clocks and the microwave investigation of rotational spectra of gases. For the latter, he employs a parallel plate capacitor type resonator whose high precision endows it with a quite high Q. Frequencies of 60 and 120 kMc were quoted as being employed in this resonator and its two disks were then 10 to 20 wavelengths in diameters. Special adjustments on the polished plates are provided to insure exact parallelism. Prokorov pointed out the ease of employing a Stark modulation voltage on this cavity. For maser use they are investigating mixtures and compounds of aluminum oxide with chromium, titanium, cobalt, and vanadium iron and copper. He showed me three operating atomic clocks for which he quoted a stability of about one part in 10^{11}. Later, I learned that Prokorov and his

Winston E. Kock is director and general manager of the Bendix Aviation Research Laboratories in Detroit. Before joining Bendix in 1956, Dr. Kock was director of acoustics research at the Bell Telephone Laboratories.

A visit to the Institute of Radio Techniques and Electronics of the Soviet Academy of Sciences in Moscow. Standing, center: Academician Vladimir Aleksandrovich Kotelnikov, director of the Institute. At right: Prof. Andrey L. Mikaleyan. Seated: Prof. Berkmann, the author, and Prof. Adantagy.

The author, left, and Prof. A. M. Prokorov of the Physics Institute Imeni P. N. Lebedev of the Academy of Sciences.

colleague G. N. Basov have been nominated for a Lenin Prize for this work.

His group is also doing some work in radio astronomy and they plan to use masers in the first circuits in the receivers. The radio telescopes are located quite a bit south of Moscow, however, and my schedule did not permit a visit there.

Prokorov then called Prof. Kotelnikov, and Kotelnikov suggested that I address his group at the Academy of Sciences. I agreed with the proviso that my talk would have to be in English. It was, accordingly, set up to occur on the day of my visit to Kotelnikov's Institute, which started with a rather lengthy tour through the Institute and ended with my talk in the afternoon. One of Kotelnikov's associates, Prof. Pistolkors (who is also an Academician and whose work is known in America), had written me that he would unfortunately be on vacation that week. Kotelnikov conveyed Pistolkors' regrets, indicating that he was off mountain climbing in the Caucasus. Kotelnikov first described briefly the various fields of effort at his Institute and then asked if I had any preference in view of the shortage of time. I selected the microwave, solid state, and electron tube fields.

Extensive work is under way at the Institute on microwave waveguide transmission using the circular electric (low-loss) mode. They are fairly conversant with the work of the Bell Telephone group at Holmdel and plan to employ regenerative pulse code modulation in their applications. Using six nanosecond (millimicrosecond) pulses, they indicated that they can observe impedance irregularities in the waveguide which are down 60 to 70 decibels. An operating transmission system used a 3-cm traveling wave tube r.f. amplifier, a distributed i.f. amplifier of 90 db gain, and pulse regeneration at each amplifying point. They eventually plan to go to much higher r.f. frequencies and are considering using the 3-cm circuitry as a first i.f. amplifier. They showed me several forms of mode filters and mode converters, one built so recently that Kotelnikov himself had not previously seen it. It operated by first converting a rectangular guide dominant TE_{10} mode into a TE_{20} mode. The guide was then flared to produce the circular low-loss mode. Long lengths of waveguide stretched through the halls for this project; their laboratory is in the heart of Moscow and extensive real estate for lengthy outdoor experimental waveguide runs is presumably not readily available. They have a 60-meter-long recirculating circular-electric mode guide which is said to be accurately straight to within ± 1 millimeter. They quoted having observed losses at 8-mm wavelengths of 2 db per kilometer. The line is supported every 1.3 meters.

Although Pistolkors was away, his colleagues discussed some of the work in his area. They are investigating the tensor permeability of ferrites at 9100 Mc. and 9600 Mc., using a thin plate of ferrite in a low-loss cavity. Magnetostatic modes in single crystals of manganese and garnet are also being investigated. Prof. A. L. Mikaleyan has built ferrite amplifiers of the electromagnetic type using a pump power of 500 watts, and is now working on a magnetostatic-type ferrite amplifier.

The solid-state work at the Institute covers a fairly wide range of effort. They grow both germanium and silicon single crystals. In germanium grown from a graphite crucible they have observed lifetimes of 2000 to 3000 microseconds. They have investigated doping germanium with most of the class III–V elements and also with copper, gold, and nickel, and are working on a theory of the mechanism of recombination in germanium. They obtain their pure silicon by a decomposition of silicon hydride (SiH_4) which deposits on a tantalum rod heated to 950°C. The deposit is pure, but of course polycrystalline, so they pull new single crystals from the melted silicon. They quoted their single crystals as having resistivities of 1000 and lifetimes of 1000 microseconds. They have constructed, for parametric amplifier use, junction diodes whose dc characteristics have suggested satisfactory performance as parametric amplifier diodes. However, this work is just starting.

In the field of electron tubes, Dr. Z. S. Chernov, head of the microwave tube research at the Institute, is exceptionally prolific in ideas. Oddly enough, he was one of the few who spoke practically no English and all of our discussions had to be interpreted. He is perhaps best known for his development of the electrostatically focused traveling tube which he calls the "spiratron". In this tube, a special cathode ejects the electrons into spiral path between an outer metal cylinder and an inner coaxial metal rod. A dc voltage between rod and cylinder tends to force the electrons toward the center rod by a $1/R$ law ($R =$ radius of spiral path). The centrifugal force of the moving electrons, on the other hand, tends to drive them toward the cylindrical shell by a $1/R^3$ law. Somewhere between the rod and the cylinder, these two forces are equal and a very stable beam path is claimed. Coupling between r.f. wave and the electron beam is accomplished by a helical conductor as in the usual traveling wave tube. The outstanding advantage of the spiratron is the avoidance of the heavy bulky magnet, which at high frequencies must also be made very precisely in order to provide proper focusing. Chernov showed me tubes said to have flat amplifying characteristics from 8- to 20-cm wavelengths, gains ranging between 25 to 40 db with 10-watt output, and 25% efficiencies. Chernov indicated that the same principle had been successfully applied to the design of backward wave oscillators.

Using the spiratron focusing principle, Chernov has built several electronic resonators, where the resonant frequency of the device is determined, not by the physical structure, but by the period of revolution of electron bunches. These bunches revolve in a spiratron coaxial structure which is curved so as to close back on itself and thus form a coaxial toroid. The inner part of the toroid's shell is open to permit coupling between an electromagnetic wave on a helix and the revolving electron bunches inside the toroid. By varying the dc voltage between the center conductor and the outer conductor, the location in space of the spiral beam of electrons is changed and similarly the period of the revolution of the electron bunches. Change of the dc voltage was said to result in changes in the resonant frequency of 2 to 1. The resonator is used to control the frequency of an oscillator, or used in conjunction with an amplifier. Chernov is also working on a new microwave technique involving the interaction of electromagnetic waves with a plasma.

My talk proved to be a rather unique experience for me. There is only one foreign language, German, in which I am even modestly proficient. Except for a few words like "Spaseeba" (Thank you) I know no Russian at all. My interpreter coached me in the preparation of an opening sentence in Russian which simply said, "I cannot speak Russian so I must unfortunately present this talk in English." However, following Kotelnikov's suggestion that I speak quite slowly and make liberal use of the blackboard with diagrams, curves, and figures, I was apparently able to convey some information to the audience of about fifty people. The dozen or so questions which followed my talk (most of which were in Russian and therefore had to be interpreted to me) suggested that my topic, "Microwave Lenses", had been at least partially understood. Kotelnikov had been aware of my earlier lens work and had readily acquiesced when I suggested this as a topic.

My most striking impression was created by the large amounts of up-to-date Russian-made research equipment. It surprised me, for example, that Prokorov had microwave generators for 2.5-mm wavelengths and the associated measuring equipment. Although much of their equipment is undoubtedly laboratory made, nevertheless it is a Russian product. When I visited Bangalore, India, last year, Sir C. V. Raman of the Raman Institute and Prof. S. Bagavantam, Director of the Indian Institute of Science, had both visited Russia shortly before and had expressed a similar surprise at the extent of the development of scientific equipment in Russia. During my stay at Bangalore, Dr. Palmer Craig, a visiting professor in a program to create a vacuum tube know-how in India, constructed the first special vacuum tube ever assembled in India. Bagavantam and Raman had indicated that before the war this same situation existed in Russia and they were surprised at the relative speed with which Russia was approaching the sophistication of countries like England, France, Germany, and the United States.

In conclusion, I should like to stress another impression, which I had received earlier, but which was more or less confirmed by my visit. This dealt with the great emphasis which is placed in Russia on science and education. There is one all-encompassing Academy of Sciences, its president has the status of a cabinet minister, and the Academy is directly responsible to the entire Council of Ministers. When a scientist becomes an Academician, he receives a very substantial salary and is usually appointed to an important position in one of the Institutes. The eight departments of the Academy include not only (1) Physics and Mathematics, (2) Chemistry, (3) Geology and Geography, (4) Biology, and (5) Technical Sciences, but also (6) History, (7) Economics, Philosophy and Law, and (8) Literature and Language. In other words they regard science as a comprehensive discipline covering even such subjects as history, law, and literature. The Scientists' City in Siberia is another example of their stressing science education. Although just starting (the University there has, I understand, only 300 students at the present time) it is eventually supposed to be the residence of tens of thousands of scientists in various fields.