# Crystal Balls and Glass Bottles



*Case histories showing how Soviet electronic R&D can point to future military systems.*

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During the summer of 1952 American XXXXXX technical intelligence officers met near Frankfurt/Main with a German electronics engineer recently returned from Leningrad. This "Dragon" returnee[1] described in some detail a costly development project then under way in the Svetlana Works engineering department, where he had been assigned by the Soviets.[2] The project was to design a novel radar tube, unusually large, with a very high peak power output, operating at metric (VHF) wavelengths, and having a duty cycle (percentage of time active) several times higher than was then common practice for pulse radars. This first-hand report provided authoritative confirmation of information reported earlier by other returnees. The Germans thought the project quite ambitious, in view of the rather primitive technology then prevailing at Svetlana. It had a further meaning for us.

Scientific and technical intelligence officers have always clung to the belief that any early tip-off on future military systems can be found in appropriate aspects of selected R&D efforts, so that intelligence on adversary R&D can give our own planners and policy makers valuable lead time. Outside the field of national security, the validity of this concept has been demonstrated in the engineering industries, where competitive industrial intelligence has used it for several generations. Its potential in the U.S.-Soviet competition is perhaps best illustrated with respect to Soviet pulse power tube technology. The development of pulse power tubes is directly and uniquely related to radar evolution, since in general radar comprises the exclusive end use for these devices. And although military radars are subject to stringent security, the USSR is relatively free in publishing specifications for many classes of pulse tubes.

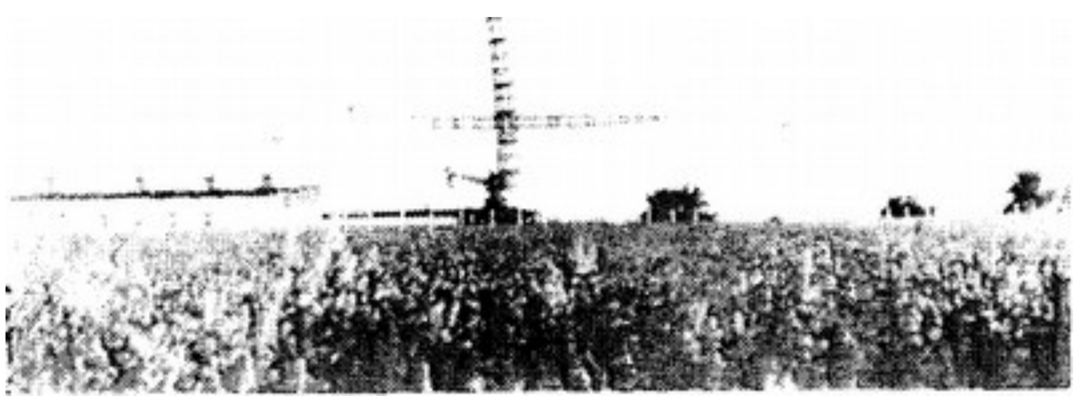
## The Tall King

The importance of the story from Svetlana was the strong evidence it provided of a Soviet intention to continue with a major effort to develop and employ VHF radars—those with a wavelength on the order of one meter. The United States XXXXXXXX largely as a result of wartime priorities and acquired skills, were emphasizing the development of centimeter wave (UHF) radars, discounting the potential of VHF on the grounds of poor resolution. The Soviets, however, had used pulse triodes[3] operating in the VHF bands in the majority of their wartime ground and naval radars, and now they were evidently being impelled by considerations of their own—perhaps their acquired know-how or the VHF's greater range capability and freedom from clutter—to mount a big development program in VHF radar technology.

The technical intelligence officers were thus aware at an early date of the continued Soviet interest in VHF radar. On top of these reports of the attempt at Svetlana to develop a superpower device for it came the introduction, between 1952 and 1954, of updated versions of earlier VHF air-defense radars, the P-8 and P-10. Then in 1954 a Soviet vacuum tube catalog (acquired with some difficulty) listed a pulse triode type GI-5B, the electrical and mechanical specifications for which corresponded almost exactly with the data provided by our Dragon source from Svetlana. Apparently the long and expensive development job there bad been successful, and the device was being put into production.

That surmise was confirmed by a team of East German electron tube specialists who visited Soviet facilities in 1956. A copy of their trip report revealed that the GI-5B pulse triode was in fact being produced in the Svetlana factory. Then a year or two later a team of American electronics specialists were invited to visit the USSR and, by coincidence, were able to examine in some detail the Svetlana production line for this tube. The important feature of their report was the observation that the production rate was extremely high for a specialized device of this nature; there seemed to be a crash program to meet a heavy immediate demand.

This accumulation of evidence now provided a firm basis for predicting that a new Soviet air-defense ground radar would be deployed shortly, that it would operate at a frequency between 150 and 200 MHz, and that its purpose would be the long-range detection of small, high-altitude aircraft targets. And so it was: in 1959, approximately five years after the GI-5B triode went into production and nearly ten years after its design project was started at Svetlana, the P-14 (Tall King) early-warning radar appeared in the Soviet air-defense network. As against published specifications for the tube's frequency, pulse length, and duty cycle-200 MHz maximum, 11 microseconds, and 0.0033 maximum-the measured values for the P-14 were 169-175 MHz, 8-12 microseconds, and 0.0025. The P-14 still remains the main extended-range early-warning sensor in the Soviet bloc air-defense system.



# The Hen House

But Soviet R&D did not stop there. Abundant information acquired over the next two years, mainly from unclassified industry publications, showed that an extensive Soviet effort in product development had been established to provide still more advanced pulse power tubes for VHF radar service. In particular, two high-power triodes dating from 1958 and 1959 merited attention. These tubes, types GI-4A and GI-24A, had a close family resemblance to the Svetlana GI-5B, with a similar peak power and operating frequency. Both of them, however, were designed to operate at much greater average power, pulse length, and duty cycle and were water-cooled.

These features indicated intended application in systems which involved large fixed ground installations and sophisticated data-processing to cope with targets at very long ranges. By early 1963, accordingly, it was possible to foresee that Soviet defense system projects could be expected to include

> large fixed ground VHF radar systems operating at frequencies between 150 and 200 MHz, employing high average powers and megawatt peak powers at high duty cycle, for use at extreme ranges against small high-altitude targets. At least two different projects appear probable, with parameters compatible with antimissile and antisatellite system requirements.

At this point the technical intelligence officers ran into a familiar occupational hazard of their craft—unsolicited advice from experts who knew better. U.S. tests in the Pacific had demonstrated that high-altitude nuclear explosions are likely to black out radio propagation in the lower frequency ranges. This was sufficient proof for the "experts" that extreme-range antimissile radars in the VHF band would not be practical and that the Soviets could therefore not be planning any such systems to operate at frequencies below 500 MHz.[4]

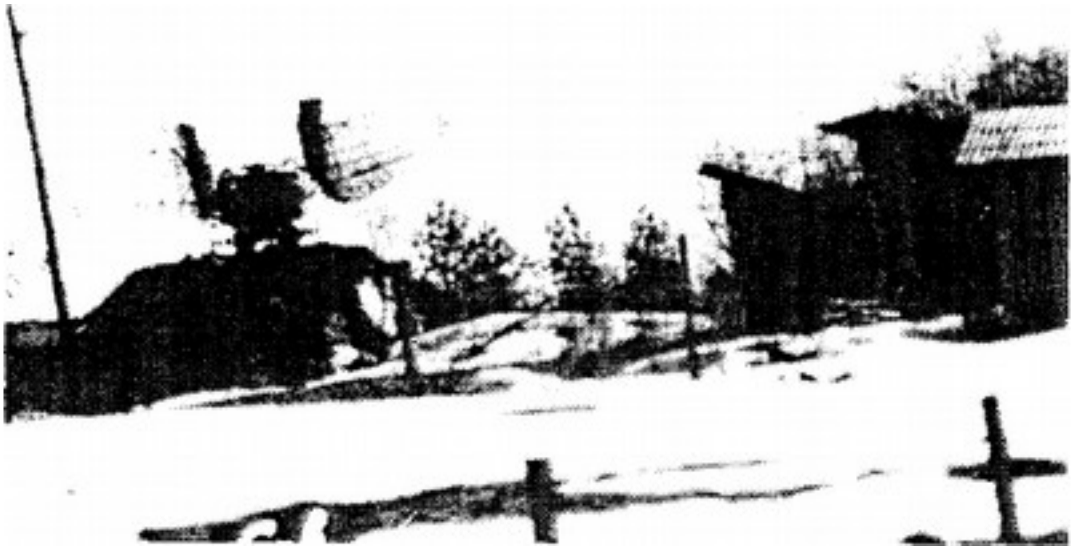
The Soviet decision-makers, however, not having the benefit of this advice, continued with their program; and in 1967 the now famous Hen House antimissile and antisatellite radars began transmissions from their operational sites. Their operating frequency lies between 154 and 162 MHz, compared with the published values of 150 and 177 MHz for the GI-4A and GI-24A triodes respectively. They use long pulses, pulse compression, and frequency scanning, with sophisticated data processing. The duty cycle of one group is 0.027 and that of the second 0.05, compared with published values of 0.03 and 0.05 for the two pulse triodes. Assuming that it is the GI-4A and GI-24A pulse power triodes they are using, these complex defensive systems first became operational approximately seven years after the introduction of their tubes.

## Back Net

Although the USSR has been far less free in disseminating technical data on radar power tubes in the centimeter wavelength bands, useful intelligence information can be obtained. In 1964 a Czech electronics expert emigrated to the United States. Some years previously both he and his director at Tesla had made business trips to Soviet facilities working on magnetrons and klystrons. From him we learned specific details about some multi-megawatt pulse magnetrons designed for operation in the "18 centimeter" band that were in production by 1957 at a Moscow factory.5 He also described a multi-megawatt klystron amplifier development that had started in Moscow in 1957 and was well under way at Fryazino during 1961.

At the time of our discussions with this Czech engineer, only two relatively low-power Soviet radars were known to operate in this wavelength region. Neither was a likely candidate for the large magnetrons described. Clearly, a new Soviet high-power centimeter wave ground radar could be expected imminently. In 1965 the Back Net air defense radar was confirmed to be just that. Operating at several frequencies between 1700 and 2400 MHz, it is the newest unit deployed at Soviet Bloc ground-controlled intercept stations

` The "18 centimeter" band would cover approximately 1600 to 2400 MHz. In the United States this portion of the UHF frequency range, although used for communications services, has not been used for radar. and in addition is being installed as the target acquisition radar for the new Soviet long-range surface-to-air missiles.



As a final word, one must keep in mind that analyzing selected products of the Soviets' R&D is useful to give a broad index of their technological capabilities for designing new military systems. In the narrower sense of predicting their deployment of particular systems, the opportunities for this approach are limited and the batting average is bound to be low. In the field of pulse power tubes here discussed, two very significant trends in Soviet radar capabilities are apparent from what we have learned. First, centimeter wave radars employing frequency-controlled klystron power amplifiers rather than magnetrons can be expected; to date, no known Soviet radar makes use of this sophisticated design that is important both for defense against electronic countermeasures and for better accuracy in measurements. Second, the techniques for precise control of signal phase and frequency values which increase the flexibility and quantity of target information in the Hen House type of system may be used at any operating radar wavelength whenever military requirements justify the expensive complication.

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# BIBLIOGRAPHY

1 During 1945 and 1946 several hundred German electrical engineers and scientists were taken to the USSR and used, with the support of a number of technically qualified POWs, for R&D on behalf of Soviet

electronics technology. By 1951 Operation Dragon had been established as an organized effort to elicit intelligence information from these and other German specialists as they returned to Germany. (For the application of Dragon to the German atomic scientists, see Henry S. Lowenhaupt's "On The Soviet Nuclear Scent," *Studies* XI 4, p. 13 ff.) Most of the electrical engineer—proceeded without much delay to West Germany for employment in its rapidly growing electronics industry. Subsequently, attracted by the pay scale and other ideological features, quite a few participated in a third "brain drain," emigrating to the United States.

2 The Svetlana Works was, and still is, a prestige engineering-manufacturing enterprise for electron devices. In the late thirties Svetlana facilities and technology were modernized with American contract support. In the winter of 1941-42, with Leningrad under siege, most of the plant was evacuated to Novosibirsk. After the war it was slowly rebuilt to its former preeminent position, though for some years its facilities were in poor shape.

3 The triode is an electron tube with three elements-the cathode and anode, say filament and plate, between which the electrons flow and a third element, say a grid, which controls the flow. The amplification is achieved by other means, externally applied magnetic fields and el;: : tric potential, in UHF and microwave power tubes, the magnetron and the klystron amplifier.

4 For the effects of this long unresolved disagreement, see David S. Brandwein's "Interaction in Weapons R&D," *Studies* X11 1, p. 18 f.

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