R. A. LEWIS

Innovation in the USSR: The Case of Synthetic Rubber

On a midwinter day in Moscow at the very end of 1927, a package containing two kilograms of a substance, similar in color to "lime-flower honey,"[1] which had been christened "Diolefin" by its makers was deposited with the scientific and technical council for the chemical industry of VSNKh. Just over four and a half years later, on a summer day in 1932 in Iaroslavl' five hundred kilograms of this same material were removed from an autoclave in a newly built factory. These two events are seen as marking the beginning and end of the development and innovation of synthetic rubber, one of the success stories of the First Five-Year Plan; for the Iaroslavl' plant, SK-1 (*Sinteticheskii Kauchuk*-1), with a design capacity of ten thousand metric tons, was the first large-scale plant to be built anywhere in the world. Before 1932 was out, another plant was operating at Voronezh and, in mid-1933, a third was commissioned at Efremov between Voronezh and Tula.

Although a vast number of new products and processes were introduced into the Soviet economy during the years of the First Five-Year Plan, the major part of this technology was imported from abroad.[2] Synthetic rubber was a field in which indigenous Soviet development occurred at a time when innovation based on domestic scientific and technical expertise did not match the rapidly growing investment of funds and manpower in research and development.[3] In spite of growing government concern and attempts to improve the innovation process, the overall performance of the Soviet economy in developing new products and processes was poor and the barriers between research and successful innovation remained considerable. These barriers fell into three broad categories: the pattern of resource allocation, the organizational structure, and the environment in which research and development was carried out—that is, the wider economic system of which the research and development network was a subsystem. The negative effects of the pattern of resource allocation were felt through the chronic shortage of development facilities, a shortage that had obvious consequences for the conversion of laboratory research into industrial technology. More spending on development and less on research might have increased the flow of innovations. A feature of the organizational structure for research was

1. It was thus described by V. A. Ostroumova-Lebedeva, the artist wife of S. V. Lebedev (V. V. Tikhomirov, *Oshibka Edisona* [Moscow, 1973], p. 38).

2. For an extreme view of Soviet dependence on Western technology, see A. C. Sutton, *Western Technology and Soviet Economic Development* (Stanford, 1971); he considers synthetic rubber to be one of only two major items which could be called the result of Soviet technology (ibid., p. vii).

3. For a fuller discussion of innovation in these years, see R. A. Lewis, "Industrial research and development in the USSR 1924–1935" (Ph.D. diss., University of Birmingham, 1975), pp. 264–99.

the administrative separation of research establishments from the industrial enterprise; furthermore, the research establishments, largely concentrated in Moscow and Leningrad, were far removed from the newly developing industrial areas. As regards the conditions for R&D, any inherent opposition to innovation was greatly increased by the economic planning system's emphasis on gross output as the main criterion of plan fulfillment, resulting in resistance to any action which could lead to a decline in the rate of production, as was likely to occur during the tooling-up and commissioning period for a new product or process. In addition, it appears that large-scale importing of foreign technology put barriers on the use of the results of Soviet research. Industrial technical policy was geared toward the utilization of imported know-how; and the organizations responsible for the design of new plants, which were the foundation of the industrial development program, were geared toward the import of foreign technology. A commonly held view was that any Soviet development was a priori inferior. It is against this background that I will review in this article the construction and commissioning of SK-1. I will examine the factors that enabled synthetic rubber to be produced at Iaroslavl' in July 1932 when other potential innovations were not pursued. I will also discuss the events surrounding the synthetic rubber project as a case study of the methods used in the implementation of the crash industrialization program of the First Five-Year Plan.

The synthetic rubber initially named "Diolefin," which was to be produced at Iaroslavl', was developed by Professor S. V. Lebedev and a small group of researchers in Leningrad, first at the Military Medical Academy where Lebedev was a professor, and, after 1925, in a laboratory at Leningrad University as well.[4] Called in the Soviet Union sodium divinyl rubber (*natrii-divinyl kauchuk*), it was a polymer of butadiene with sodium used as a catalyst; it is now commonly called polybutadiene. The raw material from which butadiene, the monomer, was produced was ethyl alcohol, which was available from existing alcohol factories. It was Lebedev's product that won the famous competition—which VSNKh had announced in the spring of 1926 with a closing date of January 1, 1928[5]—for the best method of producing synthetic rubber from material readily available in the Soviet Union.

The fact that such a contest was held was a manifestation of the Soviet leadership's continuing interest in the possibility of finding a domestic source of rubber and of ending the Soviet Union's reliance on imports of this strategically important material, which came from areas controlled by imperialist powers. During the work on producing Diolefin for the competition, V. P. Krauze, the only party member on Lebedev's team, was successful in obtaining the help of S. M. Kirov (head of the Leningrad party organization) in acquiring funds for the research.[6]

4. On Lebedev's research work, see K. B. Piotrovskii, *Akademik S. V. Lebedev osnovopolozhnik promyshlennogo sinteza kauchuka* (Moscow-Leningrad, 1950), pp. 10–22; and A. I. Iakubchik, "Sergei Vasil'evich Lebedev," in *Sergei Vasil'evich Lebedev: Zhizn' i trudy* (Leningrad, 1938), pp. 6–12.

5. In fact, the idea of holding such a competition was not completely new. During the First World War, the Treugol'nik rubber factory had set up a similar competition offering a prize of one hundred thousand rubles (see A. M. Maksimenko and Iu. S. Musabekov, *Boris Vasil'evich Byzov 1880–1934* [Moscow, 1972], p. 59).

6. S. V. Krasnikov, *S. M. Kirov v Leningrade* (Leningrad, 1966), pp. 98–100.

Compared to what happened later, the pace of events after the closing date for entries in the competition was relatively leisurely. In February 1928, a preliminary judgment by the jury under Academician Chichibabin favored Diolefin, and a special commission was established to carry out a more detailed study of the method by which it was made. Final approval was followed by a decision made by VSNKh's Scientific and Technical Administration (which apparently hoped to raise the necessary funds from the rubber industry) to push ahead with plans for building a pilot plant.[7] At the same time, there was also a proposal that work be continued on Professor B. V. Byzov's method of producing synthetic rubber based on oil rather than alcohol. In response to the decision to proceed with a development program, Lebedev presented VSNKh with a plan for future work at the end of July 1928; the plan envisaged a year and a half more of laboratory work to collect the data for building a pilot plant and another year and a half to be spent on constructing the plant and putting it into operation. After discussing the project, Lebedev was given somewhat more money than he had originally asked for and, in early autumn of that same year, the laboratory at Leningrad University became a laboratory for synthetic rubber financed by Rezinotrest, the trust for the rubber industry. In addition, an installation for producing two–three kilograms of polybutadiene a day was at the laboratory. By December 1929, Lebedev considered that enough work had been done to enable construction of an experimental plant.[8]

Meanwhile, the First Five-Year Plan for the rubber industry estimated that total production would grow three and a half times, with the main area of expansion being in the manufacture of industrial rubber goods; the number of tires produced was to grow eleven times. Greatly increased demand for rubber, which such output targets entailed, coupled with heightened international tension at the end of the 1920s, increased the government's desire to find alternative sources of supply. This question was reportedly discussed at the November 1929 Central Committee plenum and by the Politburo in December.[9]

The development of a synthetic substitute for natural rubber was only one possible answer to the problem; another solution was to produce natural rubber within the Soviet Union by cultivating rubber-bearing plants which would survive in the Soviet climate. Indeed, the Central Committee decree of December 25, 1929, which was the outcome of discussions at the highest levels of the Communist Party, was mainly concerned with expanding the cultivation of rubber-bearing plants. At the time, this seemed to present the shortest route to self-sufficiency and the decree envisaged the production, in 1930/31, of two thousand metric tons from *khondrilla*, a plant which was native to Kazakhstan.[10] Nevertheless, work on synthetic rubber was also to be continued with some urgency. VSNKh was ordered to undertake testing in pilot plants of both Lebedev's and Byzov's processes, and Rezinotrest's attitude toward the scientists' work was sharply criti-

7. Tikhomirov, *Oshibka Edisona*, pp. 39–40.

8. Ibid., pp. 41–43; S. P. Sergienko, *Akademik Sergei Vasil'evich Lebedev (Zhizn' i nauchnaia deiatel'nost')* (Moscow, 1959), pp. 86–91.

9. V. S. Lel'chuk, *Sozdanie khimicheskoi promyshlennosti SSSR: Iz istorii sotsialisticheskoi industrializatsii* (Moscow, 1964), p. 290.

10. The decree was published in *Pravda*, December 31, 1929; self-sufficiency through the cultivation of rubber-bearing plants was also the view of the rubber industry (see Lel'chuk, *Sozdanie khimicheskoi promyshlennosti SSSR*, p. 293).

cized. High priority was placed on the supply of materials and equipment for development work from both domestic and foreign sources. From the time of this decree and the decision to build pilot plants for polybutadiene production, matters concerning work on synthetic rubber were much more closely supervised by the central government. The STO—the Council for Labor and Defense—was to be involved in future developments. In February 1930, the STO discussed the details of future work with Lebedev, Byzov, and Nikiforov, the head of the newly created "association" for the rubber industry, Rezinoob"edinenie, which had replaced Rezinotrest as a result of the reform of the industrial administration at the end of 1929. It was proposed that the pilot plant for the Lebedev process, Experimental Plant "B" (*Opytnyi zavod liter "B"*), be built within ten months at the site of an idle alcohol purifying plant in Leningrad's dock area. Kirov himself chose the head of the pilot plant.[11] Rukhimovich, a deputy chairman of VSNKh, was given personal responsibility for overseeing the supply of equipment and material for the plants and granted the power to issue decrees (*rasporiazheniia*) in the name of the STO. When Rukhimovich became commissar of transport a few months later, the responsibility was passed on to Unshlikht.[12]

Design work began in April and at the same time the construction of a small experimental installation was started; the installation was to study certain aspects of the production process and to provide a supply of polybutadiene for the manufacture and testing of various "rubber" products,[13] some of which were apparently sent to the Sixteenth Party Congress, held at the beginning of July 1930.[14] However, from Kuibyshev's speech to the congress on the progress of the Five-Year Plan, it is clear that domestically produced natural rubber was still considered to be the way to self-sufficiency: in referring to the freeing of the Soviet Union from total dependence on imported rubber, Kuibyshev spoke only of plans and measures to increase the growing and harvesting of rubber-bearing plants.[15] Nevertheless, in the beginning of August, on the basis of the successful work of the recently built experimental installation—the pilot plant design had just been approved by the STO—the presidium of VSNKh decided to begin work on designs for a full-scale plant that would produce nine–ten thousand metric tons of polybutadiene per annum. The aim was to start construction during the 1930/31 building season and Rezinoob"edinenie was ordered to set aside ten million rubles in its control figures for this purpose.[16] The plant was to be designed by the same team that had designed pilot plant "B". Toward the end of the year, the Bureau for Synthetic Rubber, which had been formed under Rezinoob"edinenie in June, looked into the question of a site for this plant and selected Iaroslavl' as the most suitable,[17] because a giant plant for the manufacture of rubber and asbestos products was under construction there and because it was

11. S. P. Sergienko, *Sinteticheskii kauchuk (Istoricheskii ocherk)* (Moscow, 1940), p. 183; A. I. Iakubchik, "Raboty S. V. Lebedeva v oblasti polimerizatsii nepredel'nykh uglevodorodov," in *S. V. Lebedev,* p. 16; Tikhomirov, *Oshibka Edisona,* pp. 47–50.

12. M. A. Lur'e, "Istoricheskaia spravka," *Sinteticheskii kauchuk,* 1, no. 1 (1932): 45 (hereafter this journal will be cited as *SK*).

13. G. B. Pekov, "Vospominaniia o stroitel'stve i rabote opytnogo zavoda lit. B," in *S. V. Lebedev,* pp. 58–59.

14. Tikhomirov, *Oshibka Edisona,* p. 55.

15. V. V. Kuibyshev, *Izbrannye proizvedeniia* (Moscow, 1958), pp. 205–6.

16. Lur'e, "Istoricheskaia spravka," p. 47.

17. Ibid.

located in a potato-growing area, and at that time potatoes provided a major source material for alcohol production.

Thus, by the beginning of December 1930, construction of pilot plant "B" was nearing completion and the importance accorded to work on synthetic rubber had led to a decision to start work on the designs for a full-scale plant without waiting for the full results of a testing program at the experimental level. At that time, it was difficult to imagine, however, that within two years, two plants would have been built and a third would be nearing completion. However, in December 1930, work on synthetic rubber was to be given a new degree of importance and become a project of the highest priority.

The end of 1930 was a time of extreme optimism about targets for the First Five-Year Plan. There was no peak that could not be conquered. A massive leap forward in industry was to occur in 1931. Production of motor vehicles was to be nearly four times greater than in 1929/30.[18] Such figures had obvious implications for the production of tires and the rubber industry. The consumption of rubber in 1931 was probably calculated to be 75 percent greater than in the previous year,[19] but substantial excess demand for rubber products was also anticipated.[20] Moreover, it was undoubtedly becoming clear by this time that growing rubber within the Soviet Union was not going to provide a quick answer to the problem of the need to import a rapidly increasing amount of rubber; rubber plants were, for example, perennials which needed several years to reach a suitable size and maturity for harvesting, and attempts to increase the yield of rubber from them were not proving very successful.[21] Meanwhile, products had been made from the polybutadiene from Lebedev's experimental installation, and, while the rubber industry may have remained skeptical about the whole project, it did have support at the highest levels, notably from Kirov.

Against this background of extremely ambitious plans for accelerated industrial growth, sometime in December 1930, the Politburo discussed a report on the progress of the work on synthetic rubber, presented by Maximov, who was now head of Rezinoob"edinenie. A decision was taken at the meeting to build ten factories immediately. The Soviet historian V. S. Lel'chuk, basing his claim on archival sources, states that it was Stalin who insisted on this figure.[22] It was

18. E. Zaleski, *Planning for Economic Growth in the Soviet Union 1918–1932* (Chapel Hill, N.C., 1971), pp. 158–59.

19. Consumption in 1929/30 was 15,740 metric tons, and an article published toward the end of 1930 gave a 1931 plan figure of 26,800 metric tons (M. Nikiforov, "Rezinovaia promyshlennost' SSSR k XIV godovshchine Oktiabria," *Zhurnal rezinovoi promyshlennosti*, 6, no. 11–12 [1931]: 186 [hereafter this journal will be cited as *ZRP*]). This figure was linked to an upward revision of 30 percent in the output plan for the industry in mid-1931 (see E. G. Belyi, "Promyshlenno-finansovyi plan Rezinoob"edineniia na 1931 g.," *ZRP*, 5, no. 2–3 [1931]: 3, and Belyi in *ZRP*, 8, no. 2 [1932]: 83). A sign of the growing importance attached to the rubber industry was to be its transfer from category B to category A industry in March 1931 (see Nikiforov, "Rezinovaia promyshlennost' SSSR," p. 184).

20. In an article on the original 1931 plan it was stated that 30 percent of estimated demand for tires would not be satisfied and the proportions in other branches of the industry were even higher (see Belyi, "Promyshlenno-finansovyi plan," p. 4).

21. See G. G. Bosse's report to the Third All-Union Meeting on Rubber-Bearing Plants (*Kauchukonosy*), entitled "Sovremennoe sostoianie nauki o kauchukonosakh i ee blizhaishie zadachi," reprinted in *ZRP*, 6, no. 9 (1931): 104.

22. Lel'chuk, *Sozdanie khimicheskoi promyshlennosti SSSR*, p. 300.

clearly intended to achieve self-sufficiency in rubber in one stroke.[23] Opposition to this proposal appears to have come from Rudzutak and also possibly from Kirov, who favored an expanded program of work on synthetic rubber but, because of his long association with the research going on in Leningrad, knew better than anyone else what such a decision entailed. And when Lebedev heard the plans, he apparently sent the two leading party members from the project—Pekov, head of the pilot plant, and Krauze, the chief engineer there—to Kirov to voice their opposition.[24] It appears that those who disagreed with Stalin had some success in modifying the extremely ambitious proposals, since the STO decree of January 1931, which implemented the Politburo's decision, envisaged the immediate construction of "only" six factories, three of which were to be put into operation at the end of 1931.[25]

While these high-level discussions were taking place, pilot plant "B" was put into operation (December 18, 1930), and the first butadiene was produced; but a month and a half passed before Lebedev's team was able to polymerize the butadiene successfully. In view of the circumstances, it is probably not surprising that the "initial lack of success greatly upset S. M. Kirov."[26] Meanwhile, an urgent review of possible sites for the two plants—other than Iaroslavl'—was conducted. These plants were to be made operational by the end of the year. A site next to the Bobriki chemical combine was rejected on the basis of insufficient water supply and unsuitable nature of the ground, and sites were located in Voronezh and Efremov.[27]

While pilot plant "B" was trying unsuccessfully to polymerize butadiene, a commission from Rezinoob"edinenie arrived in Leningrad to review Lebedev's and Byzov's work on synthetic rubber, presumably to decide which method should be used at the plants to be built. In fact, Byzov's pilot plant, *Opytnyi zavod liter "A"*, was not yet completed,[28] and no final decision was made on the feasibility of building a full-scale plant using his process. In another place at another time it would seem surprising, in view of the difficulties being experienced at pilot plant "B", that the commission came to the conclusion that it really was possible to produce a synthetic rubber on a large scale by using Lebedev's method.[29] But in the Soviet Union at the start of 1931, in light of the Politburo's decision, it would, perhaps, have been surprising had the members of the commission not

23. The choice of the figure ten would seem to suggest that the Five-Year Plan target for rubber consumption was by this time around one hundred thousand metric tons; 1932 consumption was in fact just over thirty thousand metric tons (see Iu. Eremaev, "Sozdanie sovetskogo kauchuka," *Kauchuk i rezina*, 1937, no. 11, p. 49). In addition to ambitious planning and strategic interests, the growing foreign trade problems of the Soviet Union may have exerted some influence over such a decision (see Michael R. Dohan, "The Economic Origins of Soviet Autarky 1927/28–1934," *Slavic Review*, 35, no. 4 [December 1976]: 613–22).

24. Lel'chuk, *Sozdanie khimicheskoi promyshlennosti SSSR*, p. 300.

25. This is reported by Lur'e ("Istoricheskaia spravka," p. 46). Lel'chuk (*Sozdanie khimicheskoi promyshlennosti SSSR*, p. 300) states that "on the insistence of Stalin, the STO approved the maximum variant."

26. Pekov, "Vospominaniia," in *S. V. Lebedev*, p. 59; Tikhomirov, *Oshibka Edisona*, pp. 61–65.

27. Lur'e, "Istoricheskaia spravka," p. 47.

28. It was finished in the spring of 1931 (Maksimenko and Musabekov, *B. V. Byzov*, p. 71).

29. Lur'e, "Istoricheskaia spravka," p. 46.

quickly recommended a go-ahead. Any obstacles could be seen as nothing more than examples of "production risk" which could be overcome by Bolshevik efforts; any remarks casting doubt on the feasibility of building full-scale plants could be branded as technical conservatism, and indeed, only two months previously, such views had been in the dock at the industrial party trial. Nevertheless, in recommending the building of full-scale plants, those involved did make some attempt to point out that it was a leap into the unknown. A. N. Kartsev, a member of the commission, is quoted as saying: "We do not have the kind of guarantees that we have in the case of a tractor factory. In the latter instance if there are any technical shortcomings, any faults in the technology, then the design is perfected, and we can be certain that although it may take two to three months, or a year, a design fault will be corrected and the plant will run at full capacity . . . in this case we cannot be sure of this."[30] Furthermore, as Lebedev himself pointed out, starting to design a full-scale plant immediately—that is, before the completion of a testing program at the pilot plant—would mean basing the design, as in the case of the pilot plant itself, on the original laboratory data.[31]

It seems likely that remarks on the need to obtain more information before proceeding did lead to some delays in starting design work, since the outline design (*eskiznyi proekt*) for a full-scale plant was not finished until the middle of May, to be approved by a new commission at the beginning of June.[32] However, the design was still largely based on data from work on the laboratory scale, with some as yet unproven changes. Thus, it was proposed that polymerization was expected to take six days when large blocks actually took one and a half to two months, and blocks of one–two hundred kilograms took fifteen–twenty days to polymerize; and total losses of butadiene were expected to be 5 percent when in the pilot plant the losses were several times greater.[33] As the design was being reviewed, the first foundations were being laid in Iaroslavl'.[34] The hazards of telescoping the development process became sharply evident when, with the construction of the plant well under way, the butadiene converter had to be completely redesigned.[35] Because it converted the alcohol into butadiene, the converter was one of the key elements of the whole process. The design change was necessitated mainly because of corrosion, which was caused by the use of potassium nitrate to maintain an even temperature within the converter; and this probably became apparent as testing work at the pilot plant continued. In a full-scale plant the corrosion of the copper that was used in the construction of the converter meant the replacement of ninety tons a month. Moreover, copper was in very short supply,[36] and fifteen hundred metric tons of copper were

30. Lel'chuk, *Sozdanie khimicheskoi promyshlennosti SSSR,* pp. 298–99.

31. Ibid., p. 299. Lebedev appears to have remained doubtful of the wisdom of proceeding at such a pace; at a meeting with Kirov, Kuibyshev, and Ordzhonikidze in August 1931, he was unenthusiastic about taking on the supervision of the construction of the full-scale plants, asking for time to think it over, in response to which it is reported that "Kirov winked at Ordzhonikidze and Kuibyshev; 'O.K. to agree, leave it to me'" (Krasnikov, *S. M. Kirov,* p. 105).

32. Lur'e, "Istoricheskaia spravka," p. 47; Sergienko, *Sinteticheskii kauchuk,* p. 183.

33. A. I. Gelikh and V. P. Komarov in *SK,* 1, no. 1 (1932): 16.

34. *Dvadtsat' piat' let zavoda sinteticheskogo kauchuka* (Iaroslavl', 1958), p. 8; Tikhomirov, *Oshibka Edisona,* p. 77.

35. O. Osipov[-Shmidt] in *Pravda,* August 27, 1932; Tikhomirov, *Oshibka Edisona,* p. 84.

36. In 1931, production of refined copper was less than in 1929/30 (*Sotsialisticheskoe stroitel'stvo SSSR,* ed. A. S. Mendel'son [Moscow, 1935], p. 190).

needed for the construction of the converter. Therefore, the aim of redesigning the converter was not only to provide a corrosion-free method of maintaining an even temperature but also to substitute, where possible, other materials for copper; one saving seems to have come from the use of enamel. Shortages of material also caused a further change in the production process at the very last minute, when because of a lack of turpentine—used to recover the butadiene produced by the reaction of the alcohol—kerosene was substituted.[37]

An important feature which distinguished the building of the polybutadiene plants from other construction projects undertaken during the First Five-Year Plan was that there was little foreign experience to be studied, and no technological system which could be imported, at a time when the Soviet Union had virtually no chemical engineering industry; and parts of the production process depended on equipment which could withstand high pressures or temperatures or both. It was, of course, possible to purchase individual items of equipment abroad, but only a small proportion of all the equipment in the plant was imported.[38] In any event, one factor which promoted reliance on domestically produced equipment may have been foreign manufacturers' inability to supply items within the specified time. Thus, the *Pravda* article celebrating the opening of SK-1 referred to the fact that complicated pieces of the plant had been built in the Soviet Union after German firms had promised delivery only in a year.[39] The manufacture of the equipment for the Iaroslavl' plant apparently presented great problems to some of the engineering plants involved. The same article reported that an important item of the plant had been consigned to the scrap heap upon arrival at the construction site. As a result of limitations in production capabilities, some of the factories manufacturing equipment made changes in the designs received from SK-1 designers. A writer who had been involved in building the plant lamented the fact that the builders had not been able to consider the production capabilities of potential suppliers of equipment and therefore could not allocate orders accordingly.[40] In addition, there were delays in the delivery of equipment, resulting from the failure of subcontracting factories to deliver parts on time to the principal assembly plant; equipment on the Iaroslavl' site also had to wait for particular parts. There were shortages of building materials as well, and when a temporary railway line was built to supply the material, its use was delayed by a hunt for secondhand rails.[41]

Just as little foreign equipment was purchased for the construction of SK-1, so little use was made of foreign specialists; there is reference only to one German engineer who helped in the assembly of part of the plant.[42] There were few Soviet specialists capable of coping with the technology involved in SK-1; an immediate consequence of the absence of a chemical engineering industry in the Soviet Union was the lack of chemical engineers. Lagodin, the head of plant construc-

37. O. Osipov[-Shmidt] in *Pravda*, August 27, 1932.

38. Ibid. A recent writer gives a figure of 5 percent (see T. N. Mit'kova, *Pervenets SK: Iz istorii Iaroslavskogo zavoda sinteticheskogo kauchuka* [Iaroslavl', 1965], p. 37).

39. O. Osipov[-Shmidt] in *Pravda*, August 27, 1932.

40. A. G. Gorodishcher in *SK*, 1, no. 2 (1932): 21.

41. Ibid.; L. P. Brezhneva, "Deiatel'nost' Iaroslavskoi partiinoi organizatsii po razvitiiu rezinokhimicheskoi promyshlennosti v 1931–1934 godakh," in *Iz istorii organizatsii Verkhnego Povol'zhia*, ed. N. V. Gerasimov, part 2 (Iaroslavl', 1967), pp. 27–28; Tikhomirov, *Oshibka Edisona*, pp. 77–78.

42. Mit'kova, *Pervenets SK*, p. 39.

tion, was a heating and ventilation engineer. Most of the qualified personnel were recent graduates: 75 percent of all engineering and technical personnel employed by the administration for building the synthetic rubber plants in mid-1932 did not have industrial experience.[43] The problem was compounded by the novelty of polybutadiene production. Under these circumstances, the prime function of the pilot plant in Leningrad became the training of personnel for synthetic rubber plants, and its staff played an important role in commissioning SK-1.[44] The rate of labor turnover was also high, averaging 47 percent per month between January and October 1932.[45] Living conditions at the site probably accelerated the rate, particularly in the early months of construction.[46]

All of these features, of course, were common during the hectic industrialization drive of the early 1930s. An issue of a journal devoted to chemistry and the chemical industry—which appeared in the month when the first polybutadiene was produced at Iaroslavl'—included material on the state of the construction program in the plastics industry, a branch, like synthetic rubber, based on the industrial application of polymers; this revealed the critical position the branch found itself in as a result of the difficulties detailed above. The distinguishing feature of the construction of SK-1 was that, in spite of such problems, the plant was built in a year, at a time when the industrialization drive itself was showing signs of grinding to a halt.[47] Unlike the plastics industry and, indeed, most of the rest of industry, synthetic rubber plants were given very high priority, as evidenced by the production of newly designed equipment for Iaroslavl' in such a short time and by the appointment by the presidium of VSNKh of a special representative (*upolnomochennyi*) with substantial powers to oversee the building of the plants.[48]

The party played a crucial role in ensuring that the priority accorded to the plants by the state organs was implemented. Party organizations closely supervised work at Iaroslavl'. At the end of March 1931, even before work had begun, the Iaroslavl' city committee ordered the city soviet to consider all questions concerning the construction of SK-1 as a matter of immediate priority and to take any action necessary within twenty-four hours; at the same time, it took steps to send members of the Komsomol and newly qualified specialists to the site. When a party committee was set up at the construction site in July 1931, the city committee sent one of its department heads to be its secretary . Later in the year, with work proceeding more slowly than planned, the city committee sent a troubleshooting commission to the site to offer proposals for accelerating work. SK-1 also came within the purview of the Ivanovo oblast committee; in August 1931, for example, the city committee, Ivstroiob"edinenie (the organization responsible for putting up the plant), and the oblast SNKh were all severely criticized —the last of these bodies had apparently been sitting on orders for materials for the new plant which were to be provided from within the oblast; the SNKh was

43. O. Osipov[-Shmidt] in *Pravda*, August 27, 1932.

44. Gelikh and Komarov in *SK*, 1, no. 1 (1932): 16–17; Mit'kova, *Pervenets SK*, p. 41.

45. *SK*, 1, no. 3 (1932): 2.

46. Tikhomirov, *Oshibka Edisona*, pp. 80–82.

47. See R. W. Davies, *The Soviet Economic Crisis of 1931–1933*, University of Birmingham, Centre for Russian and East European Studies, SIPS, Discussion Paper, no. 4 (Birmingham, 1976).

48. Tikhomirov, *Oshibka Edisona*, p. 75.

given seven days to distribute these orders to the relevant organizations. At the site itself, the party and the Komsomols exercised unceasing pressure, through such measures as the formation of "storming" and Komsomol "shock" (*udarnyi*) battalions. In an effort to accelerate the manufacture of equipment for SK-1, they also approached the Komsomol organizations at the factories which supplied it.[49]

The Soviet government's support of the development of synthetic rubber was based on its appreciation of the growing strategic importance of rubber and the Bolsheviks' ideological commitment to science and technology. Soon after the Revolution, interest was shown in the possibility of becoming self-sufficient in rubber; yet, when Lebedev's team succeeded in gaining Kirov's support, it was as a consequence of a commitment to science and technology rather than of any hope of a quick pay-off. The result was support both for work aimed at growing rubber-producing plants in the Soviet Union and for work on finding a synthetic substitute. The pace of events between the VSNKh competition for a synthetic rubber and the production of polybutadiene at SK-1 closely reflected the increasingly frenetic activity of the First Five-Year Plan as well as the role that assignment and implementation of priorities came to play in the industrialization drive. Initially, determining the speed of future work was basically left to the scientists. The Central Committee decree of December 1929 increased the priority accorded to work on synthetic rubber and brought it more closely under government supervision but, as we have seen, the cultivation of rubber-bearing plants was considered to be the most likely road to self-sufficiency. With respect to synthetic rubber, the kind of pressure which the decree envisaged was pressure on behalf of the scientists rather than on them; it was aimed at making sure that they had sites for pilot plants and that they got the necessary materials and equipment. As the industrialization program was accelerated and targets were pushed ever higher, however, specialists were losing what control they had had over technical developments. Similarly, in 1930, control over the polybutadiene project was passing out of the hands of the research and development team. The August 1930 VSNKh decision to start designing a full-scale plant, when the pilot plant was not yet constructed, probably marked a step in this direction, although information on Lebedev's view of this proposal is not available. The events of December 1930 and January 1931 completed the change, with polybutadiene seized on as the answer to the escalating demand for rubber. By mid-1931, Kirov was "leaning on" an unenthusiastic Lebedev, resulting in a drastic telescoping of the development process and the proposed rapid construction of several plants at the same time. Although the original ambitious deadline was not met, the extremely high priority given to the building of the plants enabled them to be erected quickly, at a time when the industrialization effort itself was running into a multitude of problems.

The high priority distinguishing the development of synthetic rubber from the vast majority of Soviet industrial research resulted in measures which offset those features of the research and development system that acted as barriers to successful innovation. Thus, considerable funds were spent on development facilities and pilot plants not only for Lebedev's process but also to further work on

49. Brezhneva, "Deiatel'nost' Iaroslavskoi partiinoi organizatsii," pp. 27–28; *Dvadtsat' piat' let*, p. 8; Mit'kova, *Pervenets SK*, p. 37; Tikhomirov, *Oshibka Edisona*, pp. 78, 82–88.

the much less proven research being undertaken by Byzov. Moreover, while potential innovations were ignored or neglected by industry in other fields, the close government and party supervision, which was a consequence of the priority accorded to this particular project, resulted in pressure on the management of the rubber industry to provide funds and assistance to the scientists; this also meant a continuing high-level monitoring of the industry's activity.

In the case of an entirely new branch of production, such as synthetic rubber, where there were no existing plants, the administrative separation of research facilities from industrial enterprises could not have the negative effects it had in established industries. On the other hand, the decision to build the first plant at Iaroslavl', close to both Leningrad and Moscow (and the two plants built subsequently were also relatively close to Moscow), was likely to mean that the links between the scientists in Leningrad, the department responsible for plant design and construction in Moscow, and the construction site itself would be closer than if the site for the first plant had been in the Urals or even further east.

Two additional factors influenced the success of Soviet science in synthetic rubber. First, there was no possibility of importing foreign technology; if the Soviet Union wanted to produce synthetic rubber on a large scale, it had to go it alone. Therefore, the typical bias of plant design organizations toward foreign models was avoided. Second, the scientists themselves must not be ignored. Despite a "traditional" predilection for theoretical as opposed to applied research among Russian and Soviet scientists, from the outset Lebedev and his collaborators clearly saw factory production as the end of their research and set out to "sell" their product to leaders such as Kirov.

The overall picture of the development of synthetic rubber and the construction of SK-1, therefore, provides an early example of the ability of the Soviet government to successfully and swiftly force through research, development, and innovation in an area to which it attaches high priority. The rapidity of the assault on "the rubber problem" was not without its costs, however. Discovery of corrosion problems in the pilot plant had entailed the redesign of an important part of the process after the construction of SK-1 had already begun. There were other changes in the design as a result of material shortages and production problems; and these problems were undoubtedly compounded by the great pressure for speed. Production quality probably suffered as well. At the beginning of 1933, the head of the Administration for Synthetic Rubber, Osipov-Shmidt, himself wrote that a significant part of the equipment of SK-1 was out of date.[50] In fact, the chickens came home to roost, for within two months of the plant being put into operation, it had to be shut down for four months (from August 15 to December 16, 1932). The major reason for the closure was the hastily redesigned butadiene converter, which had barely been tested and had proved to have serious operating defects, thereby necessitating yet another design.[51] In addition, the poor quality of the equipment caused continual leaks and losses of butadiene.[52] Indeed, that midsummer day in Iaroslavl' saw not so

50. O. P. Osipov-Shmidt, "Osnovnye zadachi rabotnikov sinteticheskogo kauchuka," *SK*, 2, no. 1 (1933): 1.

51. *Dvadtsat' piat' let*, pp. 20–22; Gelikh and Komarov in *SK*, 1, no. 1 (1932): 17–18.

52. Osipov-Shmidt, "Osnovnye zadachi," p. 3. For example, as much as 40 percent of the crude butadiene was lost while undergoing purification.

much the final act in the successful development of a large-scale process to produce a synthetic substitute for rubber as the end of the beginning. In 1933, only 1,163 metric tons of polybutadiene were produced, and it was not until mid-1934 that production levels reached original design capacity.[53]

"The rubber problem" was not solved with the successful mastering of the production of synthetic rubber. Rubber is an intermediate product; it is used as a raw material in the manufacture of a wide variety of products—for example, footwear, automobile tires, conveyor belts, and electrical insulation materials. The processing and manufacturing characteristics of polybutadiene differed substantially from those of natural rubber; its innovation and diffusion throughout the rubber goods industry was a protracted process demanding major changes in production technology, which took place in face of opposition from those responsible for running the industry.[54]

Nevertheless, synthetic rubber production did come to provide a domestic source of a material vital for mid-twentieth-century warfare. While in 1932, the year when the first polybutadiene plants were being commissioned, the Soviet Union imported 30,738 metric tons of natural rubber, by 1940 imports were down to only 18,203 tons,[55] and synthetic rubber accounted for 97,000 tons.[56] Clearly, the production of synthetic rubber proved to be an early success story of the Soviet industrialization drive.

53. Brezhneva, "Deiatel'nost' Iaroslavskoi partiinoi organizatsii," p. 47; *Dvadtsat' piat' let*, p. 17.

54. The problems surrounding the utilization of synthetic rubber by the rubber industry are the subject of continuing work by the author.

55. Ministerstvo vneshnei torgovli SSSR, *Vneshniaia torgovlia SSSR za 1918–1940 gg.: Statisticheskii obzor* (Moscow, 1960), pp. 351 and 411.

56. A. A. Guchko, ed., *Istoriia vtoroi mirovoi voiny 1939–1945,* vol. 3 (Moscow, 1974), p. 377.