A Bargain or a "Mousetrap"?

A Reused Penicillin Plant and the Yugoslavians' Quest for a Healthier Life in the Early Post-War Era

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In late 1947, an old penicillin plant that the Merck Corporation had successfully operated in Montréal for several years was dismantled and shipped to Yugoslavia to be re-erected in the empty building of an old textile plant in Zemun, a neighbourhood of today's Belgrade.[1] It was part of the so-called penicillin plant programme, an ambitious rehabilitation scheme that the United Nations Relief and Rehabilitation Administration (UNRRA)[2] had launched in January 1946. The programme included four other countries – Czechoslovakia, Poland, Belarus and Ukraine –, but unlike Yugoslavia they all received complete sets of brand-new factory equipment.

What might look like a striking example of inequality in the distribution of aid resulted from a sovereign decision by the Belgrade government. Initially, Yugoslavia was also offered new machinery, but it withdrew from the programme and entered into negotiations with Merck over its old plant. UNRRA, undeterred, upheld its commitment and paid for it anyway. It was only when the

1 This research is part of an ongoing study of UNRRA's penicillin plant programme and was funded by the National Science Centre, Poland, under grant number 2014/13/B/HS3/04951.

2 UNRRA was established in 1943 to bring assistance to victims of war and prepare for the reconstruction of war-torn countries when the hostilities were over. Offering penicillin plants instead of just sending periodic supplies of ready-to-use medicine reflects its main slogan "Helping people to help themselves". See United Nations Information Office: Helping the People to Help Themselves; The Story of the United Nations Relief and Rehabilitation Administration, New York: UN Information Office 1943, p. 13.

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shipments of machinery were received that the equipment was found to be heavily worn out and incomplete. As a result, the Yugoslavians faced enormous difficulties putting the plant back together and bringing it into operation, all the while knowing that the final product would not meet contemporary standards of effectiveness in medical therapy, technological excellence and economic profitability.

In this chapter I will take a closer look at the transfer of the Canadian Merck penicillin plant that, despite its worn-out state and technical obsolescence, was finally put to work in Yugoslavia and produced penicillin for many years. By looking at the twists and turns in the story I will try to carve out the arguments and motives of the Yugoslavian actors who chose to acquire a second-hand plant instead of opting for new equipment. This historical case will also highlight the long "lifespan" and persistence of technical installations in process industries like drug manufacturing. Of course, the re-use of machines and even entire factories is common practice in industry worldwide. In fact, in certain industries, trading used capital goods is an important part of the business. As the renowned British economist John Maynard Keynes noted: "where the instrument is not irrevocably fixed to the ground, there generally is a second-hand market".[3] When a new product or technological process is introduced, old machines can be sold to another manufacturer, for whom they may still have potential value as a means of production.[4] And unlike modern equipment, they can be operated by less trained workers, and the commodities thus made – although not of top-notch quality or sophistication – can still be sold on less demanding markets. For buyers, taking such an option into account assumes a compromise between financial efficiency and technical performance, which can easily be calculated in an investment plan.

Ideally, it is a win-win situation: the seller can conveniently offset the costs of modernisation endeavours, while the buyer can make an investment at a fraction

3 Cited after Perelman, Michael: Keynes, Investment Theory and the Economic Slowdown: The Role of Replacement Investment and q-ratios, New York: Palgrave Macmillan 1989, p. 120.

4 Another reason for disposing of old factory equipment is the introduction of tighter environmental laws. Selling on to countries with less strict regulations can be tempting for many companies. For example, both economic obsolescence and stricter environmental regulations caused a large flow of used machines from Taiwan to continental China in the mid-1980s. See La Croix, Sumner/Xu, Yibo: "Political Uncertainty and Taiwan's Investment in Xiamen's Special Economic Zone", in: La Croix, Sumner/Plummer, Michael/Lee, Keun (eds.): Emerging Patterns of East Asian Investment in China: from Korea, Taiwan, and Hong Kong, New York: M. E. Sharpe 1995, p. 123–142, here p. 134.

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of the cost.[5] In practice, however, it may also be a case of "lemons", according to George Akerlof's theory of quality and uncertainty in re-use practices.[6] In Akerlof's model of "cherries and lemons", capital or luxury goods offered for sale are more likely to be in bad technical condition than those which are not openly available but are sold among closer acquaintances or partners instead.[7] In this chapter I will consider whether the penicillin plant the Yugoslavians got from Merck was indeed a "lemon", or – to cite one of the World Health Organization officials – "a mouse trap",[8] or a "cherry" that helped to transfer penicillin technology from Canada to Yugoslavia.

The chapter is based on primary sources, mainly comprising archival records from Yugoslavian, foreign and international institutions involved in post-war reconstruction in Europe. The story of the implementation of the penicillin plant programme in early post-war Yugoslavia is absent from the international historiography concerning both UNRRA's activity in the Balkans and penicillin production.[9]

AN OFFER (NOT) TO BE REJECTED

The idea of establishing penicillin production in Eastern Europe originated in the summer of 1945, when the Czechoslovaks asked UNRRA to provide them with

5 Sometimes the economic value of used machines can be even higher than their book value. See, for example, Xue, Qi: Direct Foreign Investment, Technology Transfer and Linkage Effects: A Case Study of Taiwan, PhD dissertation, Case Western Reserve University 1979, p. 46.

6 Perelman, Keynes, p. 120; Akerlof, George: "The Market for 'Lemons': Asymmetrical Information and Market Behavior", in: Quarterly Journal of Economics 83, 3 (1970), p. 488–500.

7 Akerlof employed the example of second-hand cars to demonstrate the phenomenon whereby, because of the distrust of potential buyers, more expensive goods in better condition ("cherries") disappear from official circulation, while inferior ones – "lemons" – remain, causing even more distrust and leading to consequent price drops. Ibid.

8 This was Leslie Atkins, who supervised medical supplies at UNRRA and after its dissolution headed a similar division at WHO. His opinion is cited in a broader context later in this text (see footnote 51).

9 With the exception of the self-published account of a former employee of the first Yugoslavian penicillin plant from the 1960s which provides an eyewitness view of its development. See Bosnić, Petar: Istorija Jugoslovenskog penicilina 1945–1995, Belgrade: P. B. Bosnić 1995.

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the means to make the drug at home instead of having to rely on deliveries from abroad.[10] UNRRA agreed to this and also extended the offer to other European nations, including Yugoslavia. Each package included the delivery of a complete set of factory-new technical equipment and machinery, the strains used to grow the *Penicillium* culture and the raw materials needed for six months of operation. The offer also included fellowships for two trainees from each country, a chemical engineer and a microbiologist, who would oversee the launch of the production process. All fellows were to be trained at Connaught Laboratories at the University of Toronto under the supervision of Norman L. Macpherson, the chief designer and manager of a plant operating at the lab. The blueprints that also came as part of the offer were drawn up based on this particular plant.[11] As soon as early August, Leo Rabinović, a medical adviser at the Yugoslavian Embassy in Washington, reported the news to Belgrade.[12]

For inexplicable reasons, however, Belgrade did not react for a couple of months,[13] and when it did, the Deputy Minister of Health, Grujica Žarković,

10 In fact, the Czechoslovak government in exile had investigated this opportunity even earlier, in 1944, but at that time their request to UNRRA was not accepted. For more details on the Czechoslovak initiative and how the programme was negotiated, see Łotysz, Sławomir: "International Health Organizations and the Dissemination of Penicillin Production Methods in the Early Cold War Era. The Case of the United Nations Relief and Rehabilitation Administration Activities in Europe, and the Work of the American Bureau for Medical Aid to China in China" [in Chinese: Guójì wèishēng zǔzhī yǔ lěngzhàn chūqí pánníxīlín shēngchǎn fāngshì de chuánbò - yǐ liánhéguó shànhòu jiùjì zǒng shǔ zài ōu huódòng hé měiguó yīyào yuán huá huì zài huá shìwù wéi lì], in: Journal of the Social History of Medicine and Health [Yīliáo shèhuì shǐ yánjiū], 2, 1 (2017), p. 3–31; id.: "Knowledge as Aid: Locals Experts, International Health Organizations and Building the First Czechoslovak Penicillin Factory, 1944–49", in: Reinisch, Jessica/Brydan, David (eds.): Europe's Internationalists: Rethinking the History of Internationalism, London: Bloomsbury 2021, p. 140–157.

11 The aims of the programme are outlined in various texts, including: Łotysz, Sławomir: "A 'Lasting Memorial' to the UNRRA? Implementation of the Penicillin Plant Programme in Poland, 1946–1949", in: ICON: Journal of the International Committee for the History of Technology 20, 2 (2014), p. 70–91.

12 Ministarstvo inostranih poslova: Letter to Ministar trgovina i snabdevanje, 6 Aug. 1945, 671/11, Arhiv Jugoslavije, Belgrade, Serbia (hereafter: AJ).

13 One may assume that this delay was caused by the political turmoil prevailing in Belgrade at that time. Since defeating the German occupants, the communists of Marshal Tito had exercised real power, but it was only in November 1945 that the parliamentary election legitimised the post-war state of affairs in Belgrade. Significantly, the ministry replied a day after the election.

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responded that Yugoslavia "had never given its consent" to UNRRA buying a penicillin plant on its behalf, and more or less openly refused to take part in the programme.[14] In fact, the ministry was afraid of the costs involved in launching production of antibiotics. According to the deputy minister, such a factory would cost them at least one million US dollars (although he did not specify the source of these calculations). To that amount he added another 200 million dinars – or 4 million US dollars at the official exchange rate – for assembling the factory after its components were shipped to the country.

Žarković said that such a fortune could be used "more effectively for purchasing other medical equipment or even ready-to-use penicillin".[15] The ministry was also concerned that the plant's output was "significantly" higher than the country's actual needs. If such a factory was erected in Yugoslavia, Žarković argued, it would "have to export" surpluses of the produced drug, and the deputy minister had little faith in Yugoslavia's chances of competing on global markets. In this way, he also seemed to be suggesting that "such a factory" fell some way below the highest standards. Since further improvement in antibiotic production was widely predicted, especially with the advent of synthetic penicillin, then this gap would only increase even more.[16]

The arguments given by Žarković were as bizarre as they were unclear. Apart from the fear of what to do with the excess amount of antibiotic produced, the calculations quoted were significantly overstated, as if in deliberate opposition to the plant. The costs given in the minister's letter were three times higher than those specified in the UNRRA estimates. Besides, all expenditure incurred in the procurement and shipping of the equipment was to be covered by UNRRA – something the letter did not indicate that the Ministry of Health had understood.

On 30 January, just a few days after the programme was officially announced, the Yugoslav government officially notified the UNRRA mission in Belgrade that it did not need a penicillin factory as well as a hospital and medical supplies.[17] Michail Sergeichic, the head of the UNRRA mission in Belgrade, explained the position of the local government: "This has only been done to have money with which to buy food, which must be kept moving into Yugoslavia

14 Pomocnik Ministra narodnog zdravlja: Letter to Zavod za vanredne nabavke, 27 Dec. 1945, 671/11, AJ.

15 Ibid.

16 Ibid.

17 UNRRA Belgrade: Cable to UNRRA Washington, 3 Feb. 1946, S-1443-0000-0056, United Nations Archives, New York City, USA (hereafter: UNA).

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without interruption."[18] On 11 February, UNRRA offered the Italian government the opportunity to participate in the programme, and it gladly accepted.[19]

Additional reasons for Yugoslavia's withdrawal from the programme can be partly explained by Vladimir Kušević, a director of the General Board for Medical Production (Glavna Uprava Medicinkske Proizvodnje – GUMPRO). He went to America in May 1946 to oversee the investment purchases needed for the reconstruction of the Yugoslavian pharmaceutical industry.[20] During his three-month stay, Kušević regularly visited pharmaceutical and chemical companies throughout the United States. In August he appeared at the medical department at the UNRRA headquarters in Washington.

Whilst there, he was asked why Yugoslavia had passed up an offer that everyone else had immediately accepted. He explained that the perception in Belgrade was that "penicillin plants were vastly complicated affairs, requiring over 400 people to operate", which – as the chargé d'affaires of the Canadian Embassy in Washington commented – was "apparently too much even for the vigorous Yugoslavia".[21] Kušević hinted that his government "had been deliberately misled by some dark commercial interests who, presumably, had hoped, at a later date, to go into private and profitable penicillin production".[22] What exactly these forces were, he did not disclose.

Eventually, after their doubts had been dispelled, the government in Belgrade requested reintroduction to the programme. The UNRRA staff, "undeterred by the rather fatuous explanations", immediately began preparations for the purchase and shipment of the factory equipment. Time was running out because, according to UNRRA's schedule, all orders had to be submitted by 1 October 1946

18 Sergeichic, M.: Cable to I. Sollins, 4 Feb. 1946, S-1412-0000-0068, UNA.

19 The plant was shipped to Italy and erected there, but it was launched with much delay only in 1952, mainly because the Italians wanted to couple it with a large biotechnology research centre. For information on how they did that, see, amongst others: Capocci, Mauro: "'A Chain is Gonna Come'. Building a Penicillin Production Plant in Post-war Italy", in: Dynamis 31, 2 (2011), p. 343–362; Cozzoli, Daniele/Capocci, Mauro: "Making Biomedicine in Twentieth Century Italy: Domenico Marotta (1886–1974) and the Italian Higher Institute of Health", in: The British Journal for the History of Science 44, 4 (2011), p. 549–574.

20 Monograph on the medical and sanitation program for Yugoslavia, undated, p. 5, S-1021-0014-21-35, UNA.

21 Canadian Embassy in Washington: Letter to Secretary of State for External Affairs, 7 Sep. 1946, RG 25-3798-8286-40, Library and Archives Canada, Ottawa, Canada (hereafter: LAC).

22 Ibid.

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and all deliveries completed by the end of the following March. This strict timeline was demanded by the United States, which was the main supplier of industrial commodities within UNRRA's various programmes. As could be seen from the progress made by Czechoslovakia and Poland in the penicillin plant programme, some US manufacturers were unable to meet the orders sooner than October 1947. Nevertheless, the plant was added back to fiscal estimates for 1946 supplies to Yugoslavia as a $400,000 "additional request". This plant was basically the same design as the one Belgrade had passed over before.[23]

Initially, Yugoslavia contemplated negotiating with the United States for an extension of the delivery deadline by several months, preferably to the end of 1947. There was even a precedent for this: the delivery period had been extended for fuels, food, spare parts and materials of particular importance in the post-war reconstruction of the country. The penicillin factory could also be considered particularly high priority. Eventually, though, most likely assuming that the Department of State would not agree to such an extension, in the second half of November 1946 the Yugoslavians again cancelled their participation in the programme.[24]

YUGOSLAVIA GOES OUT ON ITS OWN

The Yugoslavians had by no means given up on their efforts to obtain a penicillin plant. Instead of counting on the continuity of supplies after the dissolution of UNRRA, however, they sought to purchase a used factory on the free market. At the end of January 1947 the Federal Commission for National Health (*Komitet za zastitu narodnog zdravlja* – KZNZ) sent Josip Milunić, a doctor of medical sciences from Zagreb and a loyal communist, to the United States to find the best offer.[25]

It is not known exactly when and where Milunić began negotiations, but by early March he had already reported from Washington on quite advanced talks with the Merck Corporation about its old penicillin plant still operating in Mont-

23 Garfield, S.: Cable to K. Sinclair-Loutit, 27 Sep. 1946, S-1414-0000-0553, UNA.

24 UNRRA Washington: Cable to UNRRA Belgrade, 20 Nov. 1946, S-1443-0000-0057, UNA.

25 KZNZ: Letter to Predsedništvo Vlade FNRJ, 25 Mar. 1947, 31/60/87, AJ. The information on securing financial resources for this purpose was taken by KZNZ no later than 20 February, see: KZNZ: Letter to Ministarstvo Spoljne Trgovine, 20 Feb. 1947, 31/60/97, AJ.

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réal.[26] If Yugoslavia accepted the offer, for half a million US dollars the factory would be dismantled, shipped to Europe and then reassembled. Milunić mailed Belgrade all the technical data he had received from Merck, along with detailed dimensions of the factory building, which had to be erected or adapted for the purpose on site. In order to get acquainted with the layout and operation of the plant while still in use, he scheduled a visit to Montréal in early March. Milunić planned to travel with Ivan Radenović, a chemical engineer working as a technical adviser to the Yugoslavian Embassy in Washington.

Milunić reported that Merck's offer included the training of two Yugoslavian specialists, a bacteriologist and a chemical engineer, who would be tasked with setting up the factory. In addition, the company promised to send in three of its own specialists to help launch production. He had no doubt that it was an attractive offer, and even the evidently poor condition of some of the devices, as well as clear signs of alterations to the piping and other instruments, did not bother him. After all, it had been "one of the first penicillin plants in America", as he explained.[27]

The first things to be replaced after bringing this plant over to Yugoslavia were the fermentation tanks. The existing Montréal tanks were 700 gallons each, while most modern factories were equipped with rows of tanks that were three times more capacious. Switching to larger containers had many advantages, such as being able to adjust the fermentation section to make streptomycin. According to Milunić, three large tanks would have to be put up once the factory was reassembled in Yugoslavia.

Other sections of the production line, particularly the centrifuges and dosing apparatus, were also in poor condition and desperately needed replacement upon reassembly. In addition, some of the technical solutions employed at Merck's plant were regarded by Milunić as being "atypical". For example, the drying

26 Milunić, J.: Cable to KZNZ, 1 Mar. 1947, 31/60/87, AJ.

27 Id.: Report to KZNZ "Izveštaj o fabrici penicilina", 11 Mar. 1947, p. 2, 31/60/87, AJ. Interestingly, a CIA report from November 1953 refers to the transferred plant as "the first in the world to produce penicillin" (see Yugoslav research in pharmaceuticals / Need for technical know-how, 12 Nov. 1953, CIA-RDP82-00047R000300510007-4). In fact, the Merck factory in Montréal was the third – after Connaught Labs and Ayerst, McKenna & Harrison Co. Ltd – to make penicillin using the surface culture method in Canada, in summer 1943. Feasby, W. R. (ed.): Official History of the Canadian Medical Services 1939–1945, vol. 2, Ottawa: National Defence 1953, p. 391. By July 1944, the installation had been converted to use the deep fermentation method, the first of its kind in the British Empire. Warrington, Charles J./Nicholls, Robert van: A History of Chemistry in Canada, New York: Pitman 1949, p. 291.

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process utilised an oil vacuum pump, while the best results could be obtained with steam pumps.

The half a million dollars that Merck wanted for the plant was more or less the value of two months' production, at least according to the company itself. Given the technical condition of the factory, Milunić considered the price too steep. In his opinion, the actual value of all the equipment was about $100,000. He also thought that the plant was priced so steeply because the company wanted to cover the profits it would lose after it was dismantled.[28] On the other hand, accepting this offer would have made the Yugoslavians self-sufficient in terms of penicillin supplies in the shortest time possible. At that time it was already evident that the deliveries of UNRRA equipment to Czechoslovak and Polish plants were experiencing difficulties, and they would not open as swiftly as initially hoped. Milunić therefore encouraged his superiors to seriously consider the matter.

According to Merck, under their management the plant produced 50 billion Oxford units of penicillin every month, one unit equaled 0.6 micrograms of crystalline compound. They made amorphous antibiotic, which was then purified to pure crystals. It was the latter fact that most appealed to the Yugoslavians in the offer. The UNRRA plant employing technology developed at Connaught Labs could only make penicillin in amorphous form, which was inferior in terms of curative power. The capacity and economy of production were similar in both cases. At the Merck plant, the production cost of 100,000 units was 18 cents, which did not differ much from the average for plants of that size. The cost of raw materials constituted some 10% of this amount, and altogether this suggested a very profitable enterprise.

Anticipating possible questions about why, then, the company was willing to get rid of such a seemingly lucrative gem, Milunić informed Belgrade that Merck planned to build a much larger penicillin and streptomycin factory in the area. This new undertaking was part of the company's strategy to keep up with changing trends in the antibiotics industry in North America. As a result of the sharp increase in demand for penicillin in the final part of the war, many new factories were built in the United States and Canada, leading to significant overproduction of the medicine and thus fierce competition on the market.

The subsequent price drop necessitated further concentration of production and cost-effectiveness measures to be taken, and in the long run smaller factories were unable to compete. To keep up with their competitors, Merck had to build a factory with a significantly greater production capacity than the one in Montréal.

28 Warrington/Nicholls, A History.

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The old machinery still had some value, though, and its production capacity was several times in excess of the demand of an average country, so why not sell it?

Along with Merck's proposal, Milunić presented another from the University of Toronto, which was a repeat of the Connaught Labs model that Yugoslavia had rejected twice already. He was ostensibly leaning toward the first option. Milunić argued that they should hurry up if Merck's offer were chosen, as other countries were supposedly now queuing up to take the plant home (although he didn't explain who these eager competitors were).[29] It is not known now whether there were actually any rivals for the plant, or whether was this just a bluff to urge the Yugoslavians to make their minds up faster. But either way, they finally agreed and Merck got the deal.

Yugoslavia allocated $700,000 for the purchase.[30] Dmitar Nestorov, chairman of the KZNZ, and its secretary Voja Djukanović kept pushing the government to hurry up and finalise the deal. They argued that the versatility of penicillin meant that it replace many imported drugs. But their crowning argument was ideological in nature: they emphasised the importance of the plant's purchase to the country's five-year economic plan, saying that "the use of penicillin would save and quickly bring back to work tens of thousands of workers, and the national economy would not suffer from a lack of manpower".[31]

When, sometime in late April, information about the planned deal reached UNRRA, it offered to cover the Yugoslavians' expenses. It is not known whether Belgrade asked for this, or if the Administration saw a chance to fulfil its commitment to provide the Balkan nations with their own penicillin, but it did secure half a million dollars for the purpose. On 28 April, the head of the Medical and Sanitation Supplies Division at the Washington headquarters, Irving V. Sollins, went to Canada to settle the details. Formally, the negotiations were carried out by the Canadian Commercial Corporation, which handled local purchases for UNRRA.

Somehow, though, while visiting Washington in mid-June, a certain Mr Low from the Canadian Commercial Corporation informed the Canadian Ambassador that "by refusing to be rushed into acceptance of an absurdly high price, they had been able to obtain a reasonable offer of $225,000 from the Merck Company".[32] Because of this misunderstanding, the deal was put on hold for another three

29 Ibid., p. 3.

30 KZNZ: Letter to Predsedništvo Vlade FNRJ, 25 Mar. 1947, 31/60/87, AJ.

31 Ibid.

32 Canadian Embassy in Washington: Letter to Secretary of State for External Affairs, 3 Jul. 1947, RG25-3798-8286-40, LAC.

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weeks until the formal acceptance of the government in Ottawa was finally received on 3 July. The contract was then signed two weeks later.[33]

TAKING IT DOWN AND PUTTING IT BACK UP AGAIN

The contract negotiated by the Yugoslavians was not only overpriced. Although its exact terms are not now known, from the way in which it was implemented it is apparent that it put the buyers in a very disadvantageous position. When in August the KZNZ sent in another of its technical experts, Novaković, to oversee the disassembly process in Montréal, the factory management would not let him in, "so he could not see the devices working".[34] He was admitted only on 5 September, when all of the control devices had already been taken down and actual disassembly of the production lines had been started by a contracted engineering firm, the Donald & Ross Company. All pieces of equipment were carefully marked and identified on a diagram that was to be included with the shipments. The process of actually sending the thus boxed-up factory to Yugoslavia was UNRRA's responsibility.[35]

Two weeks later, yet another Yugoslavian representative arrived in Montréal. This was Dr Miho Piantanida, a biochemist who headed the hormonal preparations department at the Pliva plant in Zagreb.[36] He was an eminent figure in the Yugoslavian medical world, having been the first to extract domestic insulin, which was then introduced into medical practice in 1940.[37] If he had come to Montréal to familiarise himself with the factory, he was definitely too late – there was not much of the machinery left in the building. And he was not accompanied by any microbiologists, so only half the team needed to get the plant up and running again was ultimately present.

Piantanida did not wait to oversee the shipment of the factory parts and flew back to Yugoslavia. Once there, he discovered that while he had been in Canada, the authorities had changed their minds as to where to set up the factory. The ini-

33 Zavod za Vanredne Nabavke, Ministarstvo Spoljne Trgovine: Letter to KZNZ, 3 May 1947, 31/60/87, AJ.

34 Anon.: "Postrojenje za proizvodnju penicilina (Pro memoria)", undated, 83/07, AJ.

35 Piantanida, M.: Letter to GUMPRO, 28 Nov. 1947, 31/60/87, AJ.

36 Anon.: "Postrojenje".

37 Labar, Boris, et al.: "Događaji koji su mijenjali hrvatsku medicinu. Razvoj i postignuća u struci i znanosti", in: List Medicinskog Fakulteta, 36, 2 (2017), p. 9–28, here p. 13.

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tial intention was to build a new building not far from Belgrade, but after realising that the necessary preparatory work at that location would have taken at least two years, KZNZ decided to set up a temporary plant instead. Still, before departing for Canada, Piantanida suggested that the company's facilities in Pliva would be the best choice, as Pliva had both available factory space and a skilled workforce. When he returned to the country, however, the authorities showed him an old factory that had once housed a textile company in Zemun, on the outskirts of the capital city. So when, at the end of December 1947, the *SS Marchport* unloaded its precious cargo in Trieste, it was immediately sent by train to Zemun, where it was deposited in a warehouse at the designated site.[38]

The reassembly works at Zemun began in February 1948. Piantanida was confident of his ability to set up the plant with his team only and insisted on not hiring any foreign experts.[39] In the strongly idealised narrative of the national press, the lack of knowledge and experience was replaced with revolutionary zeal. It was reported that on the first day of work, "the engineers, technicians and workers [had already] collectively made a commitment" to complete the construction by Marshal Tito's 57th birthday on 7 May 1949.[40] But from the very beginning, the reassembly did not go smoothly. In the spring of 1949, Piantanida reported to the KZNZ that although immediately after his arrival from Canada he had given his opinion on the degree of wear of the plant and its essential obsolescence, during the assembly these concerns had not only proved accurate; the situation was actually much worse than was possible to determine at first glance during the hurried disassembly process.[41] He asserted that setting up the plant at Zemun would require a significant financial outlay. A large part of the equipment had to be replaced, but "as there was practically no single piece of machinery that was not worn out, an overhaul would mean actually replacing all the equipment", which he did not consider justified. For these reasons, he recommended building a new factory instead of "patching up the old one, which in no

38 Anon.: "V naši državi bomo zgradili tovarno za penicillin", in: Ljudska Pravica (Ljubljana), 30 Dec. 1947, p. 3.

39 Anon.: "V Jugoslaviji so začeli izdelovati čudovito zdravilo – penicilin", in: Enakopravnost (Cleveland, USA), 25 Oct. 1949, p. 2. Piantanida's team included, amongst others, microbiologist Gavra Tamburašev, pharmacists Živka Pešič and Slavica Mirkovič, chemical engineers Z. Peric, A. Jovič, and A. Sekulič, and technologist B. Pavkovič. An architect named Božidar Petrović adapted the building at the old factory in Zemun for its new purposes.

40 Anon.: "Začela je obratovati tovarna penicilina", in: Ljudska Pravica, 26 May 1949, p. 2.

41 Unsigned report to KZNZ, undated, 31/08/22, AJ.

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case could meet contemporary requirements in terms of both efficiency and profitability, as well as the quality of the final product".[42]

Piantanida was convinced that the monthly production capacity of 50 billion units, as declared by Merck, was based on the purely theoretical assumption that the concentration of active substance in the fermentation broth fluctuated around 1,000 units of active substance in one cubic centimetre of broth. He believed that such a yield was simply impossible to reach due to the faulty design of the plant. Upon experimenting, he found that the aeration system mounted in the fermentation tank was insufficient for the volume of medium processed in one batch. Piantanida was of the opinion that apart from the heavily worn-out condition of the factory, this was one of the main reasons why the company wanted to get rid of it. He put it frankly: "If it really could have competed with other large companies in America, it's hard to believe Merck would have put an end to it".[43]

His view was confirmed by foreign experts, particularly Ernst Chain, whom he met at a conference in Geneva on 17 February. The meeting was jointly called by the World Health Organization and the Economic Commission for Europe, to discuss ways of assisting the beneficiaries of the former UNRRA (after it was closed down, WHO took over its unfinished health programmes) in completing their penicillin plants. The Czechs and Poles, who had already encountered serious problems with their own assembly processes, warned the international organisations that further delays in launching the plants might endanger implementation of their ambitious anti-venereal campaigns, which had been designed on the assumption of an abundance of domestic penicillin.

Piantanida went to Geneva with a microbiologist, Gavra Tamburašev, with whom he worked on reassembling the plant.[44] They examined the plans of the factory as well as photographs of the technical equipment that had already been installed at the Zemun plant. As Piantanida reported, the experts asserted that it was "completely useless to re-install this outdated plant".[45] This opinion was included in the conclusions of the conference. WHO promised to assist Czechoslovakia, Poland and Yugoslavia in bringing the production methods employed at all three factories up to date. This meant, amongst other things, providing them with Podbielniak extractors to modernise the plants' extraction departments.

42 Ibid.

43 Ibid.

44 Tamburašev was made a director of the plant and is now widely known as a "father of Yugoslavian penicillin". Bosnić, Istorija, p. 61.

45 Ibid.

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While analysing Piantanida's report of the meeting, the deputy director of GUMPRO, V. Pavlov, acknowledged the fact that the Yugoslavian factory was "actually the oldest" of all three plants discussed in Geneva and that production there would be "most likely unprofitable", at least by American standards. "This fact was known to representatives of UNRRA when they offered this factory, and also to us, when we received it."[46] But in summarising his grievances Pavlov did not mention that it had been Milunić who had negotiated the deal.

Ultimately, though, Pavlov recommended that the Ministry of Light Industry should continue construction work at Zemun, regardless of whether or not WHO kept its promises. Any shortcomings in the equipment and on the economic side of the enterprise could, according to Pavlov, be assessed only after the factory had entered operation. This was his indirect answer to the report's conclusion, which was to reconsider the practicality of further assembly work at Zemun.[47]

THE "MERCK MOUSETRAP"

In early May 1949, just a few days before Tito's birthday, assembly of the plant was completed and start-up trials began.[48] The first antibiotic sample was obtained on 31 August.[49] Although the quantity was so small as to be enough only for research purposes, the press promised the "imminent" start of full-scale industrial production. The trial run lasted until the end of September, when the workers felt that they were expected to make another grand commitment for the advancement of the party. This time they promised to run the factory in top gear.[50] This news raised hopes in Yugoslavian society that penicillin would become more widely available on the market in the coming months.

When information about the trial run at the plant came out in the West, Leslie Atkins, then head of the WHO Purchasing Division, said:

"One of their big shots gave a long lecture reciting how pharmaceutical production had increased. Says he, basing his figures on production for 1945, 'The country's production has

46 Pavlov, V.: Letter to Ministarstvo Lake Industrije FNRJ, 8 Mar. 1949, 10/55/57, AJ.

47 Ibid.

48 Anon.: "Začela", p. 2.

49 Anon.: "Naš delovni kolektiv je obvladal tehnološki proces proizvodnje penicilina", in: Ljudska Pravica, 7 Sep. 1949, p. 3.

50 Anon.: "Proizvodni plan za mesec avgust je večina tovarn in direkcij zvezne lahke industrije presegla", in: Ljudska Pravica, 7 Sep. 1949, p. 2.

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increased progressively 3,000%.' Well, with 1945 and all its troubles as a base year, my comment is 'Twice nothing is still nothing.' It will be very interesting to see what they can do with the Merck mousetrap."[51]

The opinion expressed by Atkins best illustrates the actual value of Merck's offer, but it did not change the fact that the Yugoslavians had shown enormous determination in getting into this "mousetrap" of their own accord. The fundamental mistake on their side was to accept an offer that did not include the transfer of know-how and did not even allow the Yugoslavians to assist with the disassembly of key elements of the machinery. And despite Milunić's assertions, the Yugoslavian specialists who went to Canada had not been trained.[52] The fact that the plant's devices were obsolete had been known from the beginning, but the extent to which they were worn out still surprised the buyers.

The Yugoslavian authorities blamed UNRRA and unspecified "dark commercial forces" for what had happened, but not themselves. They had even neglected the warning signs from their own negotiators sent to the United States and Canada as purchasing agents, which is what had caused all the problems in the first place. They had agreed to pay half a million dollars for the plant, despite having been warned by Milunić that the price was too steep considering the plant's condition. Only when UNRRA stepped in did Merck reduce its expectations to $225,000. Still later, when the assembly process at Zemun came unstuck, the Yugoslavians realised that it was way too much for a production line built for $40,000 during the war, and amortised several times since then. Considering its current condition and usability, they estimated that its actual cost was closer to $20,000.[53]

What was worse, when the shipments arrived it turned out that the equipment was incomplete. The entire freeze-drying section was missing, as well as a steam boiler and a machine for hermetically sealing ampoules of penicillin. As for the latter device, the signed contract had an annotation on it stating that, according to Milunić, it was not needed.[54] But it definitely was. In early January 1950, at a

51 Atkins, L.: Letter to N. Macpherson, 30 Jun. 1949, 83-016-04, Sanofi-Pasteur Archives, Toronto, Canada (hereafter: SPAT).

52 The actual text of the agreement was not accessed, and therefore it cannot be determined with certainty whether Merck did not fulfil the contract or whether the provisions in the contract differed from the initial promises made to Milunić.

53 This estimate comes from a memo, the physical document of which is incomplete. The remaining first page of the document is neither signed nor dated. See Anon.: "Postrojenje".

54 Ibid.

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special conference held in Belgrade to look for a way out of the deadlock, the new president of KZNZ, Pavle Gregorić, forgave the staff members who had been generally criticised for failing to launch penicillin production as they had promised in their commitment the previous year: "They could not come up with something that was impossible. They were not provided with even basic conditions to work, and they could not perform a miracle".[55] Gregorić even complemented them, saying that they had given "their best efforts and achieved a truly unexpected success".[56]

By "success" he was referring to their mastery of the fermentation process. At Zemun they had indeed managed to culture *Penicillium* fungi and extract salts of penicillin from the fermentation broth. However, at that point they had had to stop the procedure because of the missing freeze-drying apparatus. Growing cultures in large tanks is always a complicated process, largely dependent on meticulous compliance with procedures and the experience of staff. But the measure of their success here was the fact that the Yugoslavians had to work under very tough conditions. Out of 38 fermentation batches they made during the trial run, only half were actually successful. In eight cases the entire batch degenerated owing to a failure of the electric installation, and in several others because of an inadequate water supply.[57] Piantanida had reasons for bitter satisfaction – even before the equipment reached Yugoslavia, he had warned GUMPRO that neither the water nor the electric power supply at Zemun would be sufficient, and again recommended setting up the plant in Pliva. However, as Gregorić had reminded him, at that time all of those warnings were rejected by "the comrades" in Belgrade.[58]

Piantanida was also right in his prediction that all attempts to modernise the installation at Zemun to supply crystalline penicillin would be useless. In fact, he had been saying this since the very beginning of the assembly process. It was already 1950, and the entire world was using only this form of antibiotic, which was more effective and much easier to use and store (unlike amorphous penicillin, which had to be kept at a low temperature and lasted only a few weeks before losing its potency).

55 Anon.: "Zapisnik konferencije održane u ministarstvu lake industrije FNRJ dana 7 I 1950 godine pro predmetu proizvodnje penicilina u tvornici u Zemunu", p. 3, 10/55/57, AJ.

56 Ibid.

57 Ibid., p. 4.

58 Ibid., p. 3.

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Pavlov explained that when the decision to buy a second-hand plant had been made, the authorities in Belgrade believed that since amorphous penicillin had been in use since its introduction in medical practice in 1943, it would last for many years to come. It was only after the deal with Merck was signed that the management of GUMPRO saw the logic and practicality of shifting toward crystalline penicillin.

Figure 1. Upgrading the penicillin plant in Zemun in late 1953. The small tanks, in which a mixture is prepared for final fermentation in large tanks, were also part of the original Merck factory (Courtesy of the United Nations, UN Photo/GG, no. 156110.).

In many ways, at the beginning of 1950 the Yugoslavians no longer had any doubts that the plant was old and primitive, but they still tried to rationalise their erroneous decision to purchase it. It was argued that as a "pioneer among all penicillin factories in Canada", this plant had helped give experience to and train

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local specialists, and after being transferred to Zemun, it would play a similar role in Yugoslavia.[59] The January meeting concluded with a strong determination to complete the plant in Zemun, lest all efforts made so far be rendered futile. Realisation of the project still lagged behind, however, and industrial production was launched only in late 1950.

Aware of the shortcomings of its plant, the Yugoslavian government requested advice from WHO on how to improve it. As early as December 1950, WHO sent Macpherson, in his capacity as a penicillin expert, to survey the Zemun factory. Contrary to what Piantanida had claimed, Macpherson reported that the plant could easily be upgraded to produce antibiotics in crystalline form, but the cost of the modernisation would be around $90,000. Moreover, after the expansion and modernisation that he proposed, the plant would be able to make 30 billion units of crystalline penicillin per month – less than its nominal capacity of 50 billion units, since antibiotic crystallisation causes a loss in potency compared with its amorphous form. WHO arranged with UNICEF to pay for the new equipment and modernisation works at Zemun from residual UNRRA funds. Eventually, after a lengthy reconstruction period, on 8 January 1954 it began making crystalline penicillin at an even greater monthly capacity of 100 billion units (see fig. 1).[60] Despite these modernisation works, as well as two subsequent upgrades in 1958 and in 1966, the core of the factory was left more or less intact until 1973, when a completely new plant was erected in different location.[61]

CONCLUSION

The transfer of the penicillin plant from Canada to Yugoslavia is a startling example of technological persistence in its literal meaning as the persistence of form of a material object. It can be explained by the steadiness of the industrial process embedded within it. The example of Merck's old penicillin plant is even more significant in that the antibiotic industry made major advances in the late 1940s and early 1950s – production levels boomed, product quality increased and prices nosedived. This was partly because in principle, the process of bio-

59 Ibid., p. 6.

60 Anon.: "Recommendation of the Executive Director for an Apportionment. Yugoslavia. Penicillin Production Plant", 2 Aug. 1955, p. 1–2, E/ICEF/L. 785, UNICEF, https://digitallibrary.un.org/ (accessed 19.12.2014).

61 Bosnić, Istorija, p. 248.

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synthesising penicillin had remained unchanged since Florey, Heatley and Chain defined it in the early 1940s.

Yugoslavia's decision to base its antibiotic industry on used machinery was not an attempt to compromise between financial efficiency and technical performance, as is usually the case. It was the result of a combination of factors, primarily lack of experience and ideologically driven distrust of international relief organisations. In other words, Yugoslavia was manoeuvred into this deal by the very "commercial forces" it was so afraid of. I have argued that the main reason the Yugoslavians were tempted into accepting Merck's offer was the appeal of having their own crystalline penicillin in a shorter time than if they accepted a plant from UNRRA. But their calculations failed for a number of reasons, such as substantial existing wear and tear on the machinery and inadequate training of technical personnel. On the other hand, the Poles and Czechs also struggled with their plants. Deliveries of equipment were irregular and also incomplete, which substantially delayed the launch of production. Poland made its first amorphous penicillin in July 1949, and Czechoslovakia three months later. The antibiotic in crystalline form came even later, during in 1952 in both countries.

By purchasing a second-hand penicillin factory the Yugoslavians gained access to a technology previously inaccessible to them, which in the end contributed to the establishment of an entirely new branch of the country's pharmaceutical industry, as well as to the emerging discipline of biotechnology. Admittedly, this could also have been achieved by building a new factory. One could argue, however, that the more the local specialists had to tinker to make the old equipment work, the more effective their training was.

Assuming that the Akerlof theorem applies also to investment goods, was the Merck plant actually a cherry rather than a lemon? Was it a bargain or a "mousetrap"? The market of second-hand penicillin plants was rather limited in the late 1940s, and Merck's negotiators made the Yugoslavians believe that by overpaying they would get the best offer before others would. It certainly appeared to be a cherry, until it was found to be dramatically worn out and incomplete. But it did eventually work out, and the plant operated for nearly three decades, effectively supporting Yugoslavians' quest for a healthier life. Today, the old Merck plant still persists in the public memory in Serbia – a commemorative plaque indicates where the Zemun factory once stood, while the Museum for the History of Pharmacy in Belgrade has a small exhibition featuring the story of penicillin production in Yugoslavia. In the exhibition, a statutory plate from a fermentation tank, presumably the last piece of the original equipment sent from Canada in 1948, offers tangible proof of the material persistence of technological objects.

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