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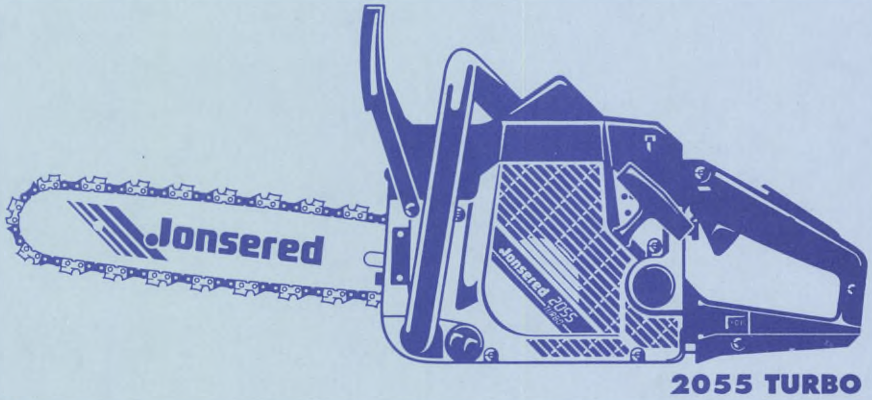

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Engineering the Biological and Political: Enabling Industrial Use of Genetic Engineering in Sweden

1. Introduction

Although things are changing, the history of technology has often involved the history of machines rather than the history of techniques. Technology includes both machines and techniques. The history of techniques in the English sense of "a practical method, skill, or art applied to a particular task"[2] seems to have been left to historians of science, who have only partially covered it. This disregard for the history of techniques has left some gaps in our understanding of how humans develop and use technology to influence and control nature.

This lack of histories of techniques is particularly relevant for one currently important, controversial, and influential set of techniques, namely genetic engineering.[3] In particular, the recombinant DNA technique (rDNA) allows controlled changes to DNA or genes, and thereby opens up new possibilities of engineering the biological world. These techniques have, in fact, been prominently used by basic scientists and industrial researchers since the late 1970s. These techniques have proven radical in a number of dimensions, such as giving some control over nature and affecting industrial production and products in a number of sectors. A quite fascinating history of these techniques can be told about Sweden.

This radical technology and its effects on society and the economy have not gone un-noticed. Much has been written about genetic engineering, biotechnology, and the recombinant DNA technique. Contributions include the history of science and of scientists who developed the technique in 1973 and of some scientists' subsequent attempts to introduce a temporary moratorium.[4] Other pieces focus more on the new and relatively abrupt involvement of these basic scientists with firms.[5] Starting in the late 1970s, many scientists in molecular biology and related fields either left the university to start small biotech firms or else simultaneously worked for universities and new or established firms. On the one hand, this led to tensions within academic science, such as disrupting communication and fueling jealousy. On the other hand, scientists' direct involvement with new and established firms sped up the diffusion of scientific results into industry. Much of the history about genetic engineering has focused on issues tangential upon science.

In contrast, not as much has been written about industrial uses of genetic engineering. To the extent that industrial uses have been analyzed, established firms within the pharmaceutical and food industries have been admonished for not having recognized the importance of genetic engineering earlier. The "biotech industry" - i.e. all the small start-up firms - has been taken as examples of how university science wedded to venture capital can stimulate economic growth.[6] However, these images of industrial use of biotechnology by no means tell the whole story.

There is another side to the history of industrial use of genetic engineering, that of some established pharmaceutical firms trying to incorporate the recombinant DNA technique into existing practise. Existing practise includes both production technologies and products. Established pharmaceutical firms like Eli Lilly in the USA and Kabi in Sweden moved in early relative to the nascent state of international basic science and relative to many other pharmaceutical firms. These firms' applications of genetic engineering occurred in parallel, as well as in direct contact, with university science. After the basic scientists' short moratorium in the mid-1970s, scientists' orientation of research were partially influenced by public debate, formal regulations, and firms' industrial goals. This side of the history of this technology has not been well described.

These pharmaceutical firms which became interested in the late 1970s in integrating genetic engineering into existing practise faced a situation of uncertainty. They faced uncertainty on all sides - scientifically, technically, economically, and politically. This situation arose largely because genetic engineering techniques were so new and had such radical implications. At this point, basic scientists had developed small scale techniques, but many questions remained. In fact, the very first firms which explored rDNA did not know whether or not bacteria could be made to produce the human proteins intended to be sold as pharmaceuticals. Science had not yet developed reliable, functioning genetic engineering techniques for firms' industrial purposes.

In another dimension, once scientists had used rDNA to modify the DNA of bacteria, the next, large scale industrial steps seemed very similar to existing biological production methods like penicillin. Nevertheless, tensions arose between the radically new techniques and the well-known technologies of biological production processes. The new and old could be difficult to integrate, as when genetically modified bacteria initially died in industrial scale vats. There were similarly economic uncertainties about the costs of these technical developments and costs of production.

Given their radical character and the emotionally loaded potentials of biological engineering, neither were the new techniques automatically covered by existing government regulation. This engendered political uncertainty about how and whether use and development of the techniques would be regulated. Scientific, technical, economic and political uncertainty thus surrounded early development of genetic engineering techniques, due to the radical newness of the technology.

The earliest history of industrial use of genetic engineering thus extends beyond firms. Uncertainty pertained not only to firms' own decisions - e.g. whether or not they would back a technical design which ultimately proved successful - but also to the scientific techniques and the production technology and to surrounding conditions. Therefore, before firms could actually start using the techniques as the basis of production, the technology and the surrounding conditions needed to become more stable.

Stabilization was necessary for subsequent technical developments for industrial use. It allowed firms to be relatively certain that they had a good chance of reaping economic benefits from their product. These returns would hopefully pay for the high costs of technical research and development (R&D) and make a profit. The earliest industrial history of genetic engineering which will be addressed here thus involved stabilization and reduction of uncertainty. Later technical development within firms was enabled by interactions between firms and the scientific and political environments which, intentionally or not, reduced uncertainty.

This article will address the early history of industrial use of genetic engineering in Sweden, mainly the late 1970s to the early 1980s. The Swedish, state-owned, pharmaceutical firm Kabi moved quite quickly internationally into genetic engineering. In 1977, Kabi's management perceived genetic engineering to be an alternative source of production for their main product, the pharmaceutical human growth hormone (hGH). Kabi therefore financed an R&D contract in the first, American, dedicated biotechnology firm, named Genentech. Genentech agreed to do R&D to try to modify the DNA of bacteria in order to "tell" bacteria to produce human growth hormone. Because no one was sure whether or not this would work, the experimental results of this R&D

contract were of both basic scientific and industrial interest. Industry and science cooperated and competed during this case. Negotiations over "blueprints" of regulation defined acceptable paths of technical development. This in turn reduced uncertainty and hence risks about whether or not a particular industrial configuration would be considered acceptable. Because firms' decisions and technical development were linked so closely to basic science and political regulation in this period, interactions among these three will be jointly examined here.

Incorporating the recombinant DNA technique into industrial production of hGH in Sweden required that both basic scientists and interested firms engineer politically as well as biologically.

2. Of scientists and debate

Following the successful development of the rDNA technique by the American researchers Stanley Cohen and Herb Boyer in 1973, many scientists in molecular biology and related fields became concerned about how the technology would be developed and used in the future. They thought regulation was appropriate. A group of prominent scientists therefore formed the so-called Berg committee, which subsequently published a letter in the renowned journal *Nature* in July 1974. This letter requested a temporary moratorium on certain genetic engineering experiments deemed dangerous.

The fears and risks expressed in the Berg committee letter were taken seriously and acted upon by Swedish scientists. Like their American contemporaries, Swedish scientists arranged meetings to spread information about genetic engineering and recognized the potential need to regulate its development. For example, in December 1974, Professors Lennart Philipson, Peter Reichard, Nils Ringertz, and Tage Eriksson informed "Forskningsberedningen", the Scientific Advisory Board to the Swedish government, about recombinant DNA. Along with scientists and politicians, the Board included several representatives from industry, such as Bertil Åberg, a medical doctor and professor of clinical chemistry who moved to Kabi.[7] No regulatory initiatives were taken by the Swedish government at this time.

Not having spurred the government into regulation of this new and untried technology, the basic scientists tried again to regulate, but under scientists' control. On the initiative of Professor Reichard, the Science Research Council formed a Genetic Manipulation Advisory Group Committee (hereafter GMAC) in 1975, which was also approved by the Medical Research

Council.[8] Swedish scientists were still concerned about the trajectory of development of genetic engineering and felt that some social control was necessary.

In contrast to the American National Institutes of Health committee which used Berg committee guidelines to regulate and which was constituted by scientists, the Swedish GMAC brought together scientists with a range of interested parties such as trade unionists.[9] The GMAC regulations followed accepted as well as changing international praxis and discussions. The committee had its first official meeting in September 1976, with Professor Reichard the chairman. It had two main functions: 1) Diffusing information about recombinant DNA out to the public and to represented organizations, and 2) Reviewing research grants. The Swedish research councils had agreed only to fund experiments which had undergone review. The GMAC committee was thereby given some control over the directions of experiments involving genetic engineering techniques.

The industrial branch most likely to be initially affected by genetic engineering - e.g. pharmaceutical companies - sat on the GMAC. Although neither Kabi nor any other Swedish pharmaceutical company had in-house R&D in molecular biology in the late 1970s, the Swedish association of pharmaceutical companies (Läkemedelsindustriföreningen, LIF) was asked by these university scientists to participate in GMAC. This indicates that scientists clearly saw in the mid-1970s that genetic engineering could soon be used by commercial firms. In Sweden, basic scientists, industrialists, and politicians thus interacted from the beginning.

LIF initially appointed the head of research of Astra, another large Swedish pharmaceutical company, as their representative: later, that person was Åberg from Kabi.[10] In 1976, the LIF representative "on behalf of the pharmaceutical companies, agreed to the guidelines that we finally adopted, the procedure we had to review any research being done in this area, whether in a pharmaceutical industry or in university".[11] In other words in 1976, the pharmaceutical association agreed to abide by the rules, even though regulation came from the scientists' committee instead of government legislation. Representation on GMAC also gave Swedish firms early information about the potentials of recombinant techniques.

Just as Swedish scientists participated in discussions and reacted to the calls of scientists working in the USA to impose a temporary moratorium in 1974, so too the Swedish media reacted to, and published, articles similar to

American ones in the late 1970s. *Dagens Nyheter*, one of Sweden's most influential and respected newspapers, published the article "Lord knows what monsters you have in your test tubes" on March 6, 1977. The article first sets up the views of a Harvard biochemist against the mayor of Cambridge, USA, then discredits the biochemist while taking the fears of the mayor seriously:

> In the closed world of science, the debate about the new and forward moving boundaries of genetic research has been going on for about five years....
>
> But the public eyes were not opened until Al Vellucci [mayor of Cambridge] sounded the alarm last year....
>
> One day when he heard about what went on in the laboratories in his city, he said straight out, 'By the devil, I would just like to know what monsters are going to crawl out of those damn researchers' test tubes'.[12]

One of the final sentences in this newspaper article - e.g. "society must take the final responsibility for the actions of individual members" - brings up a recurrent theme. The Swedish state should take responsibility for the direction of scientific and technical developments. It should tightly control these dangerous scientists, who might otherwise become real-life Frankensteins.

Starting in mid-June 1977, *Dagens Nyheter*, as the first Swedish paper to do so, ran a series of debate articles on genetic engineering. The first article, written by the Social Democrat and active debater Nordal Åkerman, was entitled, "What right does research have to be free?" Åkerman's answer in the article was very little.[13] In contrast, the second article was written by Lars Wieslander, a medical researcher at the Karolinska Institute. He reacted to the implication that there was "any connection between Harvard's [genetic] research and monsters that people had seen on the streets!" and instead detailed the scientific basics of genetic engineering.[14] The final article in this series "This concerns survival itself", again written by Åkerman, restated the need for social control of the technology.

The articles by these two authors - a critical, professional public debater and a medical researcher using the techniques - reflect an on-going dilemma in the Swedish debates about genetic engineering. On the one hand, for the medical and natural researchers, genetic engineering was something understandable, techniques that could be defined and explained. On the other hand, for many of the debaters and the public, genetic engineering meant more than understanding current techniques. To them, genetic engineering posed new possibilities and dangers, a technology which could be developed and used in unforeseen ways in the future. Communication and discussions over regulation could be difficult because of these differences in basic assumptions.

By mid-November 1977 and running through spring 1978, the Swedish debate intensified, especially the negative side. Åkerman again set the negative tone to "Stop the High Risk Laboratory!" in *Dagens Nyheter* but with other newspapers also running articles.[15] The catalyst for debate this time was the plans of Uppsala University, the Biomedicinskt centrum, to build a P3 high security lab inside the university city of Uppsala. Due to the intensity of these debates but especially due to a decision by Uppsala City Department of Health (Uppsala kommuns hälsovårdsnämnd), these building plans were shelved for the moment. Ulf Pettersson, one of the researchers working on rDNA with Philipson in Uppsala, then carried out some experiments at the Pasteur Institute, Paris, France.[16]

This incident happened at about the same time that American scientists and public debate praised new research results which addressed a fundamental question. Namely, even if DNA could be transfered between species, could bacteria really use it to make human proteins? Herb Boyer from the University of California, San Franscisco, (UCSF) carried out an experiment with the protein somatostatin which indicated that the answer was yes. Boyer was also one of the two founders of the California biotech firm Genentech in 1976. In fact, the 1977 somatostatin experiment was carried out at the university labs, but financed by Genentech.

So, just when the American media began emphasizing the benefits of genetic engineering and celebrating that bacteria could make the human protein somatostatin, the Swedish media - at least the debate articles - were emphasizing its risks. Because genetic engineering was a radically new technology, public debate in different countries played a role in shaping national public environments which would ultimately allow - or forbid - certain types of genetic engineering techniques and experiments.

Although the heated Swedish debate in late 1977 and early 1978 had many negative tones, it did not, however, stop Swedish firms from being interested in the market and technical potentials of genetic engineering techniques. In fact, quite soon after Genentech's somatostatin experiment, the Swedish pharmaceutical firm Kabi moved to investigate the potential of these new techniques for producing their main product. Kabi approached Genentech. This was one of the first firms in the world to approach basic scientists or a newly started biotechnology firm about an R&D contract involving gentic engineering. No one was then certain that the techniques would work in practise. Thus, the early Swedish public debate did mobilize opinion for and against the technology, but it cannot be seen as a decisive element affecting the technological innovation process.

3. Kabi's move into genetic engineering

Kabi had decided to investigate the market and technical potentials of genetic engineering to make its most important product, namely human growth hormone. Interesting questions in this historical process include the firm's motivations to explore genetic engineering at all. Kabi already had a production process for hGH, namely extraction from tissue. Why was Kabi interested in finding an alternative source of production for this pharmaceutical product? How and why did Kabi specifically decide and act to contact Genentech?

According to Hans Sievertsson, who was then Kabi's research director, Kabi had a small - five or six person - research group who studied the complex of proteins released by the pituitary gland and the hypothalmus, including interactions between hGH and other proteins. Sievertsson was one member of this group and had a PhD for research on hormones in the hypothalmus. Like other research groups, this corporate R&D group monitored scientific developments in the field, and one of these developments was Genentech's use of genetic engineering to make somatostatin. The Kabi group studying these proteins was not isolated inside the firm, but instead, had on-going contacts with the nearby medical research institute, Karolinska Institute.[17]

In fact, Kabi's relationships with the nearby universities and medical center had been important for the firm's whole involvement in hGH extracted from pituitary glands. In the late 1960s, Professor Luft had, in association with assistant professor Roos, suggested that Kabi make hGH. Kabi began working on pituitary hGH in 1967, started clinical tests in conjunction with Luft in 1968 and registered the product in 1971.[18]

In 1977, this small Kabi research group thought Genentech's research using rDNA to make somatostatin in bacteria was "fantastically exciting". Sievertsson recollects that it was natural for them to wonder if other proteins could be produced the same way.[19] Sievertsson therefore called Genentech during a business trip to Chicago in late 1977 to establish contact and to look into the possibility of an R&D contract for hGH.

Upon returning to Stockholm and after Sievertsson talked over matters with his boss, Bengt Karlsson, Kabi invited Swanson and Boyer, as Genentech's representatives, to Sweden.[20] Boyer and Swanson had started Genentech in

1976. Boyer was a basic scientist from the University of California, San Francisco, and Swanson was a venture capitalist.

Kabi was interested in the possibilities that the new techniques offered for producing their most profitable pharmaceutical product, human growth hormone. Kabi was a so-called pure, ethical, pharmaceutical company[21] which mainly produced pharmaceuticals based on biological processes. Kabi's contemporary production of hGH was based on extraction from human pituitary glands, making pituitary hGH. It had a small if lucrative market. Kabi thus had technology to extract, purify, and formulate the hGH present in pituitary glands into a pharmaceutical product when they contacted Genentech about genetic engineering.

Kabi also had technical and engineering experience with separation of blood products, with complex proteins, and with controlling microbiological processes such as penicillin and streptokinase. This competence and experience might be useful for new projects using relatively similar new technologies. The question was, how similar would genetic engineering be to current technologies? In other words, would genetic engineering be a radical or just incremental change from the firm's perspective? No one could foresee the answers to these questions. Technical development of a new production process had to be based on R&D using systematized knowledge and empirical experiments.

The disease hGH was intended to treat, hypopituitary or severe dwarfism, was then estimated to afflict 6 - 10 persons per million, and the estimated costs of one year of treatment per patient was $5,000 - $10,000 in 1979. Treatment lasts about ten years, up until puberty. In the late 1970s, Kabi was the world's largest commercial supplier of pituitary hGH. Kabi had 70% of the world market, with their main international competitor being Serono, a Swiss company, but there were also non-profit, government-financed agencies like the National Pituitary Agency (NPA) in Baltimore, Maryland.

For this particular pharmaceutical product, size of market was closely linked to supply of pituitary glands. In the late 1970s, Kabi collected about 150,000 glands from around the world. On average, it took 50 pituitary glands to provide enough hGH for one patient for one year so Kabi could provide treatment to approximately 3,000 patients per year.

Pituitary extracted human growth hormone thus had an established, if fairly small market. This indicated that the same product made with an alternative technology should have a similar if not larger market. Genetic engineering offered the promise of greatly increased supply. Kabi's management felt it could sell all the hGH it could make because the current supply sufficed for only the most severe cases of dwarfism. Many potential patients of this disease - hence customers - simply could not get hGH. In addition to the known and established market for dwarfism, there were indications that hGH could be used for other medical conditions like healing burns, Turner's syndrome, and so forth. Kabi was therefore interested in genetic engineering as way to supply a larger market.

Commercial firms and government-sponsored organizations had opposing appreciations of the potential market for hGH. On the one hand, Kabi clearly saw a larger market for hGH, if the supply could be expanded. On the other hand, Salvatore Raiti, director of NPA, maintained in 1979 "that all patients with diagnosed hyposomatotropism are receiving the hormone".[22] In other words, he did not see too little supply as a problem, and for that reason, no new production technologies based on genetic engineering were needed. Since the NPA was not moving to develop the technology, partly due to the organizational and institutional structures, genetic engineering threatened their *raison d'être*.[23] Without extraction of hormones, there would potentially be no NPA.

The problem with pituitary hGH was that greatly expanding the supply was not so easy. Kabi already had international contacts to collect pituitary glands from morgues, but they continually faced a situation where potential demand was greater than supply. Raw material from biological material were not only in limited supply, they were also relatively difficult to deal with. Åberg later claimed these latent sourcing needs, rather than only profit-making or availability of new knowledge, pushed pharmaceutical companies into genetic engineering.[24] Genetic engineering offered the possibility of unlimited supply of hGH because the protein would be made in bacteria or other simple cells which would rapidly multiply, each daughter cell also making the protein. Kabi thus had technical as well as market supply reasons for developing industrial uses of genetic engineering.

Expanding the supply clearly indicated the possibilities of making profits with the new techniques. Kabi was having financial difficulties and needed a boost to survive in the pharmaceutical industry in the longer term. Kabi as a firm faced economic uncertainty about the future. For example, KabiVitrum had gone from a profit of 27.2 million Swedish crowns in 1978 to a loss in 1979 of 22.3 million Swedish crowns.[25] At the same time that pituitary hGH was Kabi's most successful product and an important income-generator, Kabi teetered at the edge of bankruptcy several times in the late 1970s. Kabi's decision to pursue technical development by financing research was thus taken under conditions of uncertainty. That was financial uncertainty within the firm as well as uncertainty about whether the techniques would function in practise at a reasonable cost.

Largely because Genentech had good basic scientists and was willing to sell R&D contracts for specific industrial applications, Kabi contacted them rather than any Swedish researcher in the field. Although there was some basic Swedish research in tangential fields - above all in Uppsala, Swedish researchers did not work on the specific application of genetic engineering techniques which had attracted Kabi. At this particular time, the specific application of making hGH in bacteria required basic scientific research.

Åberg, as research director for KabiVitrum, was intimately involved in the discussions between Genentech and Kabi to purchase directed research. In a debate book from 1982 entitled *Safe enough? About the introduction of a new technology into Sweden - recombinant DNA*, Åberg reminisces about same course of events:

> I remember how Peter Reichard, professor in biochemistry at Karolinska Institute, asked me, in connection with the awarding of the Nobel Prize to Roger Guillemin - the discoverer of somatostatin - what Kabi intended to do about the new technology. The answer was that Kabi's current research director Hans Sievertsson and I, who was research director for the group Kabi-Vitrum-ACO, had already invited Herbert Boyer to come to Stockholm and discuss the possibilities for cooperation in some of the product areas that were important for Kabi. The meeting occurred in the first week of December 1977, and Boyer was accompanied by Robert Swanson, managing director for a newly formed Californian company, Genentech Inc. Kabi was represented by Hans Sievertsson and from the research side of the group, myself and my closest colleague, Kerstin Sirvell, Master of Science. It was clear after the meeting that it would be possible to clone human growth hormone (somatotropin, hGH) in a coli bacteria.[26]

In addition to Åberg, Sievertsson and Sirvell, Linda Fryklund was present at the meeting; she was department head of the Recip Hormone Laboratory at Kabi.[27] Sievertsson confirms that Boyer and Swanson came to Stockholm on "Nobeldagen" 1977, that is, December 10th, the day the Nobel Prizes are awarded. Boyer and Swanson's fee for coming was the price of their plane tickets: Genentech was interested in finding customers to whom they could sell R&D contracts on genetic engineering.

As Åberg points out, Drs. Guillemin, Schally and Yalows were concurrently awarded the Nobel Prize in physiology/medicine for their work on peptide hormones.[28] Guillemin had discovered the medical significance of somatostatin and had extracted it from tissue. *Scientific recognition* for research on somatostatin thus occurred parallel in time and within a few kilometers of the *commercial recognition* of the new technology genetic engineering to make the same and similar proteins.

The scientific versus commercial demands on quantity to be produced with the two different techniques ultimately differed by several orders of magnitude. Both Guillemin's group and Genentech's group had made about five milligrams of somatostatin, a tiny amount, before Nobeldagen 1977. However, whereas Genentech could make it in bacteria, with the potential of replicating the experiment in thousand litre tanks, Guillemin obtained his five milligrams by grinding up almost a million sheep brains.[29] Possibility to produce in large scale was a necessary condition for industrial use, thereby making genetic engineering a more interesting technical trajectory than handling biological material. Genetic engineering promised control over what was an apparently unlimited supply.

During the first negotiations between Kabi and Genentech, few outsiders to Kabi, even within Sweden, knew about the specific discussions that Åberg and Sievertsson had begun or about Kabi's general intentions to use genetic engineering. As shown above, two active Swedish researchers also involved in regulation were Reichard and Philipson. The above quote indicates that Reichard was unaware of Kabi's intentions in December 1977, and Philipson had a similar opinion as of July 1977:

> I don't think any one of them [Astra, Pharmacia, Kabi] is involved in recombinant DNA research at the present time. I don't think there are any plans to use it in the foreseeable future. But of course, they would like to have an option and a procedure to follow in case they would be interested.[30]

Of course, Philipson was right that Kabi was not involved in recombinant DNA research nor even in contact with Genentech in July 1977: Kabi's first more formal contact with Genentech was in December of that year. Neither was Kabi involved in the Swedish debates of this period, which otherwise would have indicated their interest publicly.

Following the meeting between Genentech and Kabi in December 1977, the upper research management of the Kabi companies - i.e. Bengt Andrén, Bertil Åberg, and Hans Sievertsson - made a decision to work out an agreement with Genentech to carry out research on hGH. They signed a "Letter of Intent" in December 1977, which indicated their agreement to try to come to an agreement. Lawyers from the respective companies set out to hammer out a legal contract during 1978. Kabi thus thought it likely that

Genentech could successfully carry out the research project. They signed the contract in August 1978.

Up to this point, development of genetic engineering techniques significant for the hGH project was largely based on scientific research, carried out within research institutes and acclaimed by scientists as interesting. One of these was the Boyer/Genentech experiment with somatostatin which captured the attention of Kabi's R&D management and of the American media. Nevertheless, alongside the basic scientific acclaim, Genentech's research on somatostatin had also had non-scientific objectives. This research helped develop practical techniques, like synthetic DNA. It also served as advertisement both for Genentech's scientific potential and their willingness to sell R&D contracts to other firms.

Of course, firms - whether mostly composed of researchers like biotech firms or more established pharmaceutical ones - were not the only agents trying to shape the direction of developments in genetic engineering in the 1970s. News about somatostatin and about genetic engineering in general was also used to influence public opinion. In influencing governmental and public opinion, debate influenced calls for the creation and modification of political regulation. Regulation set boundaries and directions of technical development considered acceptable.

Informal institutions and regulatory bodies for scientific experiments were set up by basic scientists in the early to mid 1970s in both the United States and in Sweden. This occurred before the public debate got underway. When the debate about genetic engineering became more public after 1976 in the US and after 1977 in Sweden, the range of fears and optimisms about the technology increased, and there were suggestions to not allow any genetic engineering at all within a community or within a nation. This negotiation, however, did not stop all scientists from carrying out experiments nor stop all firms from investigating the market and technical potentials of genetic engineering.

Clearly, with interest from established firms like Kabi and their competitors such as the American pharmaceutical firm Eli Lilly, genetic engineering would no longer be an exclusively academic development. Firms were not willing to wait around for basic research results which just happened to be applicable for industrial use. Instead, some firms financed research in universities and/or biotech firms in order to apply general scientific knowledge and techniques to specific industrial applications. These firms had to expend resources to get access to knowledge which was otherwise not available - and in order to develop techniques which no one was quite sure would work. Exploring these new technical alternatives involved uncertainty.

4. Engineering a bacteria construction

For Kabi, genetic engineering represented a new technique to make an existing product. In order to succeed with this vision, the techniques and genetically modified bacteria to be supplied by Genentech had to actually work and be integrated into existing production practise.

Because no one was sure the techniques would work, research to make hGH in bacteria was perceived to be scientifically as well as industrially interesting in 1978. In doing rDNA experiments on hGH, Genentech partially competed with a scientific group at University of California, San Francisco (UCSF).[31] Nonetheless, basic scientists and corporate scientist-engineers were ultimately trying to answer different questions with the same experiments. Basic scientists were more interested in using genetic engineering techniques to expand knowledge about how cells work. Firms wanted functioning techniques which could create value to be sold on a market.

Kabi recognized that genetic engineering represented a break with their past technical production system for pituitary hGH. If genetic engineering worked, Kabi needed to invest in R&D to jump to the technical trajectory based on genetic engineering. At the same time, Kabi management did not intend to give up the technical trajectory that the firm had developed around tissue extraction of hGH. They would retain those techniques and that knowledge as well.

In comparison with Genentech, Kabi was less focused on the genetic engineering, partly because they did not initially have this competence. Management was more focused on strategies to realize commercialization. They had to integrate genetic engineering into a production system and political environment. Tasks included obtaining financing for the R&D work, putting together an internal research group, influencing discussions about regulation, and so forth. In short, basic scientific research in molecular biology and related fields was definitely not Kabi's main activity, but Kabi tried to quickly develop the ability to take care of scientific techniques. Competition in the economic environment required the development of practical techniques on an industrial scale.

Initially, this involved keeping a close eye over the hGH research project that the Genentech scientists were doing. Sievertsson and/or Åberg travelled to South San Francisco about once a month in 1978 in order to check up on their project. Initially, however, Genentech was mainly concentrated on making insulin in bacteria for Eli Lilly.[32] In an interview, Sievertsson said that there were two main reasons that they followed the hGH project so closely - 1) Partly because it was such a major, expensive research project compared to Kabi's budget and therefore natural to see the advances first-hand and 2) Partly because of the uncertainties. At that time, it was "incredibly futuristic to think that a stomach bacteria could make human proteins"[33] and so, in other words, it seemed like a pipe dream and involved enormous risks. Kabi was curious about whether or not Genentech would be able to deliver the scientific breakthrough they had promised.

In addition to checking up on research results, Kabi had these months between December 1977 and August 1978 to plan how to take care of both genetic engineering techniques and the specific bacteria for hGH. They needed to take care of them within the firm and within Sweden.

Although Kabi had experience with biological processes, neither they nor any other firm in the world had previously worked with genetically engineered bacteria on an industrial scale. The research directors felt it imperative that Kabi develop its own experience in genetic engineering for future products. Thus, although Kabi became interested in the new genetic engineering trajectory for their main product hGH, management saw the potentials that the techniques offered for generating new products or improving production of existing ones.

To develop competence in genetic engineering, Kabi started a biotech company named KabiGen in 1978. KabiGen's first bill was about a million dollars, up-front, to pay the Genentech R&D contract. It should be emphasized that despite this strategy to develop molecular biology competences for other products, Kabi clearly relied on Genentech for the rDNA hGH project.

Åberg explains the strategy to start KabiGen as follows:

> I felt a strong NIH - Not Invented Here - complex against the recombinant DNA adventure in KabiVitrum. Bengt Andrén and I therefore thought that it was better to locate this development project to a special company, especially since one could see the necessity of Kabi acquiring its own competence in the area of recombinant DNA, if the project succeeded. So KabiGen AB was built in 1978.[34]

Bertil Åberg became the first managing director of KabiGen.[35] As Åberg puts it, "if the [hGH] project succeeded" and thereby showed that genetic engineering could live up to its perceived industrial potential, Kabi wanted close access to and control over basic research competence related to biotech.

As to why Kabi started this new firm, KabiGen, and placed the rDNA hGH project there, Åberg presents one explanation - the Not Invented Here complex, thus implying that his vision of using genetic engineering met stiff resistance within Kabi. Genetic engineering represented a new and uncertain technical trajectory for the firm. In other terms, the technology might threaten Kabi's existing core competence and experience base. In a written account, Åberg (1982) argues that Swedes in general (in public debate) and local Swedish politicians were hostile to the new technology and made its industrial development difficult.

The other upper R&D manager driving this innovation process at Kabi at the time, Hans Sievertsson says, "All innovations meet resistance" and shrugs off Åberg's account.[36] In short, innovative firms and individuals should expect resistance and act to mitigate it. Sievertsson's interpretation has been seconded by Fryklund. Fryklund continues, "This [Not Invented Here explanation] is not true. The reason for KabiGen was to permit Kabi's own development for other products. All the work done on hGH was done by Kabi [not KabiGen] scientists."[37] These statements thus indicate some conflicts between KabiGen and Kabi in the early years.[38]

KabiGen was the first biotech firm in Scandinavia. Moreover, it was a firm that was started by and initially jointly owned by Kabi and "Statsföretag", the holding company for Swedish state-owned firms like Kabi.[39] Why, then, was Per Sköld, head of Statsföretag, interested in joint ownership of KabiGen and in financing the R&D contract with Genentech? Sievertsson says that Sköld was interested because he had studied some chemistry and molecular biology, and could see the possibilities. "It doesn't have to be more remarkable than that".[40] Åberg was also very well connected with individuals and groups in Swedish public life and very energetic about creating support for genetic engineering. Personal relations build a basis for trust, which can facilitate financing for long-term or risky goals.[41] Most importantly, perhaps, Kabi was owned 100% by the state.

For whatever reason that Kabi succeeded in getting the Swedish government to finance KabiGen and hence the Genentech contract, this financing was vital for developing and integrating genetic engineering techniques into a functioning production process. Without those Swedish crowns and without Statsföretag's support, Kabi could not have moved as quickly into genetic engineering. Sievertsson indicated that without both the financial and moral support, he did not think that Kabi's hGH project would have gotten off the ground at all. In the worst case scenario, resistance within Kabi might have overwhelmed these managers' attempts to introduce genetic engineering into the company. The implication is that individuals within a firm who actively try to introduce and develop a new technological trajectory will face resistance but can overcome that by relying on support from powerful allies such as political or scientific organizations.

The Swedish state helped Kabi begin its technological trajectory into industrial use of genetic engineering in another way as well. In addition to getting money to start KabiGen and to finance the R&D contract, Kabi also immediately applied for a special 11.5 million crown loan from the governmental Industrial fund ("Industrifonden"); Kabi received the money later but Åberg and Sievertsson applied around 1978. "Industrifonden" loaned Swedish companies money for risky, large scale product development work. Such loans reduced risks for the firm as the firm only had to repay the loan if the product was successful. Much of the initial seed money for KabiGen and for Kabi's hGH project thus came from Swedish government agencies rather than from market financiers. Swedish political agencies were thus important factors explaining why Kabi was able to quickly develop genetic engineering for industrial use.

Engineering a stable political environment in Sweden was also important. Concurrent with Kabi's manoeuvrering in 1978 to build support for the new biotech firm KabiGen, the Swedish government was pressured to pass official regulation. This pressure came partly from the political necessity of acting on a hot mass media topic when there was a Parliamentary election the following year and partly from the scientists in the Genetic Manipulation Advisory Group Committee. Debaters called for the creation of government regulations to direct both scientific research and technical developments.

Åberg's account of that time stresses the intense tone of the debate and, in particular, the negative attitudes:

> A great controversy among the public creates among decision-making politicians, of course, partly agitation and partly the feeling that something must be done. Certain facts were systematically wrong in the mass media, and it is impossible to judge where this occurred due to dubious intentions, to increase the customer base or due to lack of ability to go to the scientific sources.[42]

Åberg was thus cynical about the reasons debaters had negative opinions about genetic engineering techniques, including accusing some political parties of attempts "to increase the customer base". As mentioned, a Swedish mass media debate had started in the fall 1977 over Uppsala's high-security lab and ran to spring 1978.

Kabi, represented by Åberg and his colleague at KabiGen Kerstin Sirvell, published its first significant media article about the new technology in *Dagens Nyheter* on February 3, 1978. Like the scientist Professor Philipson in Uppsala, they criticized the un-scientific tone of opponents to the technology. Just as Åkerman painted the fantastic dangers of the new technology, Kabi wanted to show the fantastic possibilities and the negative consequences of not following up technical developments in genetic engineering. More particularly, Åberg and Sirvell argued that prohibiting recombinant DNA experiments would make Swedish universities and industry dependent on foreigners and that Sweden would take the risk of losing jobs for the future. These are arguments that weigh heavily in many debates in Sweden, a small neutral country wishing to maintain high-paying jobs.

Åberg and Sirvell also called for the creation of new public regulations. These rules would make it clear to everyone which trajectories of technical developments were and were not allowable. They wanted to "Replace the voluntary reporting to the research councils' [GMAC] committee with an obligatory reporting for all researchers in Sweden active in the field! Legally see to it that the Recombinant-DNA committee gets the right to decide about prohibition or permission for certain research. Place democratic representatives in the committee".[43] Åberg and Sirvell thus called for political regulation of the new technology, including features such as democratic representation that would reduce criticism of the technology. The government did eventually react to calls for political regulation.

Indeed, the center to right, three-party coalition government decided on February 16, 1978, to empower the Minster of Education Wickström to investigate legislation for research with rDNA and to make regulatory proposals. Instead of a Government Investigation ("statlig utredning") which involves many people and much time, the Swedish government gave the investigation to the Department of Education, which in turn appointed one man. The investigator, Bertil Wennergren, was ready ten months later, on December 1, 1978, with the report *Recombinant DNA Under Control*.[44]

Wennergren proposed legislative changes to place activities using recombinant-DNA technique and molecules under the existing environmental, work place and public health laws as well as to propose a new governmental committee to take over the supervisory tasks of the Genetic Manipulation Advisory Group Committee. The new committee should propose guidelines to regulate experiments. His proposals were clearly influenced by the public environment and regulation in the United States and England. Like the Americans, Wennergren proposed that genetic engineering could be handled within existing laws. The Swedish government did not immediately act on his proposals.

Both the Swedish debate and the Swedish legislation were initially stimulated by events in the United States, but soon gathered their own momentum, where events internal to Sweden like the Uppsala lab, the election interests of political parties, Kabi's industrial interest in genetic engineering, and the Wennergren report were used to shape the future direction of technical developments in Sweden.

5. Developing politics and production technology

Parallel with debates and recommendations for legislation in Sweden, Genentech and Kabi signed their R&D contract in August 1978. It was one of the first industrial contracts in the world involving genetic engineering.

This R&D contract stipulated that Genentech had 24 to 30 months from August 1978 and forward to develop a bacteria which could produce hGH. Instead of taking so many months, Genentech came up with an initial bacteria expression system only 7 months after the contract was signed. Åberg, the head of research at KabiVitrum, and then at KabiGen, writes, "In April 1979, I got the message that the bacteria was ready and that it made hGH."[45] The Genentech scientist named first on the subsequent scientific paper, David Goeddel, says, however, that their first clear experimental results came in late May.[46]

This message came several months before either Genentech or a competing group at UCSF submitted their scientific papers to respective journals. In late 1979, both groups published scientific articles detailing how genetic engineering techniques could produce human growth hormone.[47] Genentech was under contract from Kabi and the UCSF researchers under contract from the American pharmaceutical firm Eli Lilly. These experiments in a loose sense "proved" that bacteria could make longer, more complex proteins like hGH, and the experiments also developed some useful techniques.

In this sense, the bacteria given to Kabi in spring were not "ready" in any final or usable sense. Showing bacteria could make human proteins indicated the technology could function for industrial purposes. The scientific experiments did not answer questions about the efficacy of the bacteria construction - such as how well the signals to start and stop translation worked with the DNA sequence coding for hGH. Nor did they address the commercial question of whether rDNA hGH could be produced at an economically viable quantity and price.

The scientific experiments neither proved that these bacteria could be grown on a large, industrial scale nor that the proteins could be adequately separated - i.e. purified - from contaminants. These questions had to be answered if rDNA hGH was to be accepted as a pharmaceutical. However, these were questions for the firms. The scientific papers were focused on other questions but did indicate the technology was possible. Generating the information that it was possible enabled Kabi to be confident to start organizing search activities which would generate further information about technical choices and components for a production system. Kabi had early access to the information that use of the technique was feasible.

Moving from potential to actual industrial production of hGH required the integration of many component technologies as well as their common functioning in a technical production system. The firm had many choices about which component technologies to use in a production system, but was constrained by their objective to sell the product so produced on the heavily regulated pharmaceutical market. The final product, including its technical production system, had to be approved by government agencies in order for the firm to sell their innovation. The firm's decisions about which component technologies to develop and select internally were thus constrained by existing scientific and technical knowledge, economic configuration of this market as well as public conditions.

Instead of investigating these technical developments within firms like Kabi, one could just dismiss this R&D as applied science, as problem-solving which is less innovative and inherently less interesting than basic science. According to the linear model, scientific research is more important than technical developments because science generates the true novelty. Industrial use is just application of science.

To dismiss the firms' contributions, however, would be to miss the heart of innovation processes, namely the continuing innovativeness required to apply new scientific knowledge to industrial purposes. Scientific research did not provide the once and for all answer to questions. Instead, many new challenges arose for each specific application. Industrial R&D was partly based on knowledge, techniques and equipment which had been developed by university scientist-engineers but applied to very specific, local, technical problems.

Kabi recognized that making the technical system work consistently, at high yields, and with high quality of final product was crucial for ultimate success in the economic environment. The challenges of technical development were thus quite different from those of basic science. This economic challenge required many incremental technological changes. Although the market would be the ultimate selection mechanism for the final product, firms had to make choices about technical alternatives to integrate genetic engineering into production practise. Moreover, economic variables, particularly the cost of production, would play a large role in determining the future viability of genetic engineering as the basis of a production.

Based on the knowledge that scientific experiments indicated bacteria could produce hGH, Kabi began in a modest way to bring together a research engineering group to handle the industrial production side of the project. In the spring of 1979, Sievertsson asked Björn Holmström, a microbiologist with extensive fermentation experience at Kabi, to start the rDNA hGH project.[48] This R&D work on commercial production based on genetic engineering occurred within the established pharmaceutical company Kabi, not in the specialized biotech company KabiGen. The Genentech R&D contract and initial expenses were, however, under KabiGen's budget.

KabiGen then applied for a permit from the scientists' GMAC committee, and on April 27, 1979, it got a permit to grow *E.coli* modified with an hGH gene in 10 liter scale. Because, however, neither Kabi nor KabiGen had laboratories which met the required physical safety specifications, they could not utilize the permit.[49]

Kabi's attempts to develop an industrial technological trajectory based on genetic engineering were not carried out in isolation. Their industrial use was tangential upon public debate. Kabi's plans to construct an appropriate lab to utilize the GMAC permit created controversy, including critics who argued that such innovative activities should not be carried out in Sweden. Some perceived the technology Kabi wished to develop as too risky. Some critics thus tried to stop technical developments well before any innovation had been introduced into a market.

On August 15, 1979, Kabi's plans to build "Sweden's first risk laboratory for gene research" made front page news in *Dagens Nyheter*. Kabi planned to renovate an existing, unused virus lab up to the so-called P3 standards of safety then demanded by the Swedish GMAC - and American National Institutes of Health (NIH) - guidelines. It should be a safe lab, capabable of containing relatively hazardous material. This lab was located next to their headquarters on Kungsholmen, central Stockholm.

The front page *Dagens Nyheter* article, "Criticism in Stockholm against Kabi's plans: Risky research in the middle of the city" had a critical tone, but the criticism was even more pronounced in the daily debate article.[50] The debate article was written by Guy Ehrling of the Center Party (Centerpartiet), which traditionally represented agricultural interests but had increasingly emphasized a "preserve-nature" angle. There is an underlying assumption in Ehrling's argument that genetic engineering was unnatural in the sense that humans should not tamper with laws of nature.

More specifically, Ehrling argued that research involving genetic engineering was dangerous, that a "risk lab" should not be built downtown, and that the government must take a decision to implement laws for recombinant DNA based on Wennergren's proposals in December 1978. Erhling thus wanted a cautious regulation and development of the technology, and he used public debate to try to brake Kabi's move into genetic engineering. In fact this turned out to be a very short debate running only in August 1979.[51] Kabi was silent for the moment.

Ehrling's attack on genetic engineering - coming as it did from the Center party - came at a particularly sensitive political moment. It was August 1979; Sweden had Parliamentary elections coming up in September; and a three-party, center-to-right coalition between the Conservatives (Moderaterna), Center party and the Liberals (Folkpartiet) wanted to win a majority of votes to form the national government. In the 1976 elections, a coalition government under Thorbjörn Fälldin had managed to unite these three more center-to-right parties, but in the fall of 1978, the government resigned, and the People's Party had built a minority government.[52] In connection with Erhling's criticism, this political situation would temporarily affect Kabi's range of choices about developing genetic engineering.

With the Parliamentary elections only a month away, these parties could ill afford a debate over questions which might split the future coalition and which would thereby reduce their legitimacy as an alternative governing coalition. It was no time to restart the debate over genetic engineering, particularly since 1978-79, Sweden was already in a heated and consequential debate over the future of nuclear energy. In these Swedish debates, technology was no longer seen as unequivocally positive. Questioning the viability and desirability of technology was coupled with arguments to increase social control.

In this sensitive political situation, the Swedish government, led by the Liberals, chose an alternative to a new debate on genetic engineering. They chose a temporary, voluntary moratorium on industrial experiments. At the time, KabiGen was the only firm considering genetic engineering experiments in Sweden, so this moratorium was directly aimed at them. It is thought-provoking that the moratorium came quickly after the beginnings of a debate - launched by Erhling - about whether or not KabiGen should build a lab inside Stockholm.

After the election in September 1979, with this three party coalition winning, Åberg and Sirvell explained their position in the press when the debate resumed:

> Just before the election, the government requested that Swedish industry should voluntarily refrain from doing recombinant DNA experiments until the government had organized a regulatory body and had passed a law to control such activities. KabiGen of course follows this request, which was conveyed through the daily press....
>
> We at KabiGen consider it is our duty to follow [international technical developments] and despite unclear political conditions in this question here in Sweden, we 'will save what can be saved' for the future of Swedish industry.... We are following the government's request, conveyed through the mass media, to do nothing in Sweden.[53]

Åberg and Sirvell clearly saw the voluntary moratorium on industrial experiments with the technology as a political move by the government, particularly since the request was conveyed in the public debate.

That this temporary moratorium was due to political negotiations within the coalition is substantiated by the fact that the Center party's national convention had voted in 1978 to try to implement a moratorium on genetic engineering until a broad debate had been held and legislation implemented.[54]

In contrast to the Center party, the two Kabi firms saw the temporary moratorium as well as calls for permanent moratoriums as having negative effects on their ability to compete in the economic environment. KabiGen's management argued that even a temporary moratorium had the very unfortunate consequence of slowing down their innovative activities compared to international technical developments. Whereas the Center party might have argued that slowing down technical development was a good thing for Swedish society, Kabi argued it was very bad for Swedish industry.

At the same time that Åberg and Sirvell perceived genetic engineering as a future money-maker for their own firm, the above quote also indicates that they had a broader vision of genetic engineering. Genetic engineering would affect more than KabiGen. They used the argument that genetic engineering was a necessary technology for diverse products in Sweden's industrial future. They would "save what can be saved". Instead of stringent social control, they argued that technical development would be for the public good through economic development.

Åberg later argued that hostility in the public debate was the real reason Swedish industry moved so slowly into genetic engineering.[55] Åberg overstates his case, however. The "voluntary" Swedish political moratorium only lasted three months; Swedish comprehensive legislation came into effect as of January 1, 1980.[56] Moreover, this moratorium was of no practical importance for *Kabi's* development of rDNA hGH because they were then working jointly with Genentech in California. It only - potentially - affected *KabiGen's* plans to do research on rDNA for other products. This means that the particularities of the Swedish public environment did not, in fact, slow down Kabi's work on rDNA hGH.

However, the Swedish public agencies were not giving clear signals about the extent to which they approved or disapproved of genetic engineering. From the firms' perspective, this helped create uncertainty about the future and hence uncertainty about future returns to R&D investments. On the one hand, the Swedish government called this voluntary, temporary moratorium on industrial applications in autumn 1979. This represented an informal but political mechanism against genetic engineering. On the other hand, in the longer term, the Swedish government worked towards national regulation which would clearly define what was acceptable.

Moreover, the industrial possibilities of genetic engineering had also been seen by some persons at the Swedish Board of Technical Development ("Styrelsen för Teknisk Utveckling", STU). STU was an official agency, formed in 1968, and its *raison d'être* was to enable and develop closer contacts between universities and industry in order to promote technical development for firms. In contrast to the government's brief moratorium, STU encouraged diverse industrial applications of genetic engineering in their budget from 1979. In particular, Gerhard Miksche pushed for STU support of genetic engineering for industrial uses. STU was divided into "needs areas" or research divisions, and Miksche was head of pharmaceutical technology. Another proponent of genetic engineering was Charlotte af Malmborg, who headed the division which supported research on food technology, including biotechnology.

Miksche and af Malmborg thought that genetic engineering or biotechnology could be a way to dynamize research in the food sector. In 1979, they therefore generated support for and launched a framework research program called Gene Technology. The program was to run for several years. "The purpose of this project [Gene Technology] is to build competence about recombinant-DNA technology which is directed towards the needs of Swedish industry."[57] Although STU never supported work within Kabi nor KabiGen on hGH[58], STU recognized the need to develop industrial scale processes as well as complementary technologies including, for example, process technology, process control and separation technology as well as more basic research.[59]

STU thus quickly joined Kabi's enthusiasm for industrial uses of genetic engineering. It was willing to invest large sums of money - several million crowns - into scientific research at universities and institutes of technology. This research should potentially have industrial applications.

Nevertheless, 1979 was by and large a period of uncertainty about the future for Kabi and KabiGen. They were initially not certain whether these new techniques would work nor whether they could be integrated with industrial production processes. Public conditions in Sweden also seemed to work against any ultimate success with launching an innovation in the economic environment. There was also financial uncertainty within the firm, leading to uncertainty about how to finance the expensive R&D project, even with government support. Kabi and KabiGen also faced opposition to their building plans for a P3 lab, some opposition to genetic engineering research in general as well as uncertainty about when the government would pass regulatory laws - and how restrictive those laws would be. By mid- to late 1979, however, it was clear that the Swedish government and Parliament would soon act and that more stable political conditions would arise.

Knowing that political conditions were stablizing, Kabi could concentrate on technical developments necessary to integrate genetic engineering into existing production technology. Hands-on experience and experimentation were necessary for this. So, Kabi had to find a place to actually grow cells and try out alternative production processes. For example, Kabi's fermentation expert Björn Holmström needed to learn more from Genentech about the specific characteristics of the *E.coli* bacteria strain producing hGH. The biological material had to function. This transfer of know-how from the United States to Sweden was specified in Kabi's license under the R&D contract.

For these reasons, in September 1979, Holmström worked in California with Genentech's fermentation expert Norm Lin for five weeks.[60] Like Holmström, Lin needed to learn more about the peculiarities of this bacteria strain, particularly the conditions to optimize cell growth, how to turn the promoter on, how to maximize hormone production, and so forth. In doing so, they experimented to develop a model, functioning fermentation process for their respective firms.

At this stage, these corporate scientist-engineers clearly saw fermenting - i.e. the growing of genetically modified bacteria - as a continuation of the large scale, industrial fermentation of other products like antibiotics. They had standardized equipment and techniques to start working on engineering questions. These were similar to problems and solutions used in non-genetic engineering based biological production.[61] They acted as engineers to develop and integrate genetic engineering as the basis of production.

Using existing knowledge, techniques and equipment, Lin and Holmström set to work growing the genetically modified bacteria in South San Francisco. The American restrictions were the NIH guidelines which, for example, required that the micro-organisms were killed before removal from the fermenter. Indeed, NIH guidelines were formally only for university research, but firms followed them, partly to prevent negative public opinion.

In a compromise-cooperation between the regulatory environments in the United States and Sweden, Holmström and Lin grew the bacteria genetically modified to make hGH in San Francisco, and broke apart the cells - i.e. made cell lysate - at Genentech. Thereafter, as Lin puts it:

> We would put it in bottles, freeze it and send it to Kabi for product recovery. Because at the time, we [Genentech] had just started doing recovery ourselves but I think Kabi knew much better how to purify this protein than us so they were ahead of us.[62]

Åberg and Sirvell said the same thing publicly in Sweden at the end of October 1979:

> We [Kabi] can not bring home this [hGH-producing] bacteria in the current situation. The bacteria is cultivated abroad, after which the bacteria are killed. The bacteria-free solution is then sent here to Sweden and attempts have been started to develop an industrial technology to purify the growth hormone.[63]

Note that the timing of the Åberg-Sirvell article (late October 1979) indicates that the bacteria were already producing growth hormone during Holmström's first stint at Genentech. Human growth hormone producing bacteria had an industrial scale reality as well as the scientific lab scale from autumn 1979.

Moreover, at this very early stage, Genentech and Kabi had a division of labor, each doing a complementary step of the technical production process. Åberg and Sirvell's article indicates that the reason for division of labor was the respective legislation (or lack thereof) in the two countries. In contrast, the Genentech scientist Lin emphasizes that the reason was the specialized competences of the two firms. Other scientists confirm Lin's interpretation.[64] Initially in this cooperation, both firms perceived that Kabi's experience with pituitary hGH would give them a comparative advantage relative to competing firms like Eli Lilly. The knowledge, techniques and equipment that Kabi had developed with pituitary hGH should help guide their innovative activities for a new rDNA version.

If the firms were going to successfully claim that the recombinant DNA hGH was a substitute for the pituitary version, they had to be able to purify it and to prove that their product was as identical as possible. Human growth hormone was thus a special case where the firms were trying to make a product identical to an existing product but based on a different technology. For that reason, one major concern was that the bacteria-produced hGH had one extra amino acid, a methionine; it had 192 amino acids instead of the 191 in hGH produced in the body.[65] To prove their new hGH worked as well as the old, the firms needed to have something with which to compare it. In other words, they needed to know the physical characteristics of pituitary hGH and ways to purify and test it. This is why Kabi's previous experience came in handy for the new project.

Thus, the Genentech - Kabi relation did involve transfer of genetic engineering techniques for a specific application from the USA to Sweden. Nonetheless, this initial division of labor between fermentation of bacteria at Genentech and of purification at Kabi indicates elements of mutual complementarity. Kabi viewed Genentech as a group of gifted basic scientists, who had molecular biology knowledge which Kabi lacked, but who were moving into Kabi's traditional competence areas such as fermentation, purification, and sales of pharmaceuticals. Genentech viewed Kabi as a company partly specialized in hGH, which already had a functioning purification scheme for pituitary hGH including how to test it medically.[66]

Joint cooperation could help each individual firm relative to competitors. Genentech and Kabi would not be direct competitors as they had divided up the world market.

Due to the interlocking nature of the technical production system for hGH, more than the cell fermentation that Lin and Holmström worked on was required. Kabi and Genentech also had to develop and refine all the complementary techniques and equipment needed to make component technologies function together at a cost-effective level. On the one hand, they needed to grow and purify out enough hGH to start the first phase of pre-clinical tests. On the other hand, they needed to analyze the final product in order to decide how best to develop a functioning technical production system.

To develop these complementary technologies at Kabi, the rDNA hGH project was placed into a R&D group studying peptide hormones from the pituitary gland. Although some in the group had been involved in Kabi's initial interest in Genentech's work on somatostatin, their real involvement came in 1979 with the appointment of Linda Fryklund as project leader of the rDNA hGH project.

Despite Kabi's openness in 1979 newspapers about developing a purification process for the "bacteria-free solution" in Sweden in October, Åberg has said that in December 1979 he secretly brought the hGH-producing bacteria into Sweden. As much later reported in a widely distributed, weekly newspaper for engineers, *Ny Teknik*:

> Smuggling professor made genetic engineering profitable. It began with a bacteria, smuggled in the research director's vest pocket....For six months, it lay in amidst the food in the professor's own refrigerator, and eventually ended up at Kabi.[67]

In this account, Åberg's bringing of a bacteria strain into Sweden appears to be a key step in the innovation process.

Although several observers argue that Åberg was a driving force for Kabi's move into genetic engineering and deserves much credit[68], this physical act of importing a strain of the bacteria to Sweden was just one of countless steps along the road to commercialization. Åberg's role has been over-emphasized in popular Swedish accounts to the exclusion of all the subsequent R&D at Kabi. In the case of bringing the bacteria to Sweden, for example, other variations of the genetically engineered bacteria were later brought into Sweden by Holmström or just shipped through the mail. From 1979 to the present, a variety of slightly different genetically engineered bacteria have been used by Kabi.

Moreover, according to Fryklund, whether or not Åberg "smuggled" the bacteria to Sweden was irrelevant to Kabi's R&D work. In 1979, Kabi and Genentech were running fermentation in California. Holmström and Lin were "trying to persuade the bacteria to make the right hGH. Before then it was not necessary to bring the bacteria to Sweden at all!".[69] In this view, Kabi had little reason to challenge the contemporary Swedish public agencies by smuggling bacteria because they were still having technical problems in California.

Moreover, changes to the Swedish public conditions paved the way for Kabi to ferment the bacteria in Sweden. This was expected by late 1979. On January 1, 1980, Sweden got comprehensive national legislation regulating use of genetic engineering. These changes were based on Wennergren's recommendations and replaced the research councils' GMAC with an official Delegation for Recombinant-DNA questions (Delegationen för DNA-frågor).[70] Those firms wishing to use genetic engineering now had a specific legal procedure and structure to negotiate their way through. Largely as a result of this legislative decision, the Swedish public debate trying to stop the development of genetic engineering pretty much died out. By setting clear informal institutions and formal regulations in the public environment, the government reduced the firm's uncertainty about the political future. By reducing this uncertainty, the government facilitated the firm's search activities for new technologies and technical development.

Management's desire to develop genetic engineering was tangential upon the interests of this Swedish governing body. As Gunnar Danielsson, first chairman of the Delegation and director-general for the Board on Working Environment put it, we "also wanted rules - not to prevent activities but to help them. [We wanted to create] a model to regulate activities that people could accept".[71] Stable, politically agreed upon regulation proved necessary to legitimize industrial use of genetic engineering in Sweden.

Although the political framework was in place as of January 1980, getting permission to do industrial experiments using the new technology was not immediately forthcoming. Kabi moved as fast as it could to obtain a permit. It wanted the competitive advantage of being first internationally to market the product (hGH), but their plans to develop the technology in-house were somewhat delayed by the political process. On January 3, 1980, KabiGen applied for permission to the Public Health committee to 1) Do research generally with recombinant DNA techniques and 2) Grow *E.coli* bacteria to produce hGH in a volume of max 10 litres. KabiGen intended to carry out these two activities in the now renovated virus lab in Stockholm.

The strain of *E.coli* mentioned in the application was, of course, the one developed by Genentech, namely an *E.coli* K12 strain 1776 with RV308 using the plasmid pBR 322. This bacteria strain was used to produce Kabi's first approved rDNA hGH product, named Somatonorm.[72] Interestingly enough, KabiGen's application specifically states that "the company wishes to grow this bacteria in volumes of max 10 liters in order to develop purification technology necessary to produce pharmaceuticals".[73] Industrial problem-solving for the economic environment had clear precedence over scientific research at this point, and was to direct further technical developments within the firm.

Following Swedish praxis, upon receiving the application, the Public Health committee in turn sent out the request to interested authorities for comments, and finally had a meeting on June 12, 1980.[74] The Public Health committee decision came on July 4th, but KabiGen did not get the broad permit they were seeking. Instead, KabiGen only got permission to grow *E.coli* to produce three proteins in scales up to 10 liters volume.[75]

While KabiGen was waiting for a decision in 1980, Kabi continued experimenting with the bacteria in the United States and with purification in Sweden. Kabi's R&D fermentation expert Holmström returned to Genentech several times in 1980 for several weeks at a stretch to work with Lin. There was communication between Holmström and Lin, of course, and transfer of knowledge, but the two quickly developed individualized processes in collaboration with their respective downstream processing groups.

After KabiGen was granted their permits in June 1980, Holmström - of Kabi - used KabiGen's labs to grow the hGH bacteria in Sweden, and then in November 1980 another Kabi employee, Cirl Florell, joined Holmström in fermentation. Unlike Genentech which initially had to hire new people for each new task, Kabi drew on current employees for the hGH project. In this case, both men had extensive experience in fermenting Kabi's other products like streptokinase and penicillin.

Time was of essence at this point due to competitive pressures, and this phase of innovation required much trial-and-error, empirical work to identify optimal solutions and potential problems. Initially, Holmström and Florell utilized the 10 liter limit in Sweden to the maximum by running one cultivation a day. As it takes about 7 hours to grow up the bacteria to the desired cell mass, they took turns at coming to work at 6 am. Kabi was in a hurry! During the initial R&D, sufficient money was available through the 11.5 million Swedish crowns borrowed from "Industrifonden".

The corporate R&D project group also had to decide which types of technical developments should be given priority; in other words, they continually had to make decisions about which directions to develop the complementary and component technologies. For example, in 1980, the Kabi project group got information that their 192 amino acid hGH was biologically active - i.e. human bodies could recognize it. Knowing that, Kabi and Genentech still had to prove to themselves, regulatory agencies, doctors and users that the bacteria-produced version was identical to - or at least worked as well as - the one produced in the human body. They had to marshal scientific facts developed in the medical scientific environment to support their interpretation of the relative importance of the methionine. Knowing that the met-hGH worked made getting rid of the extra amino acid less of an urgent task for the R&D group than it had been. Instead, developing a technical production system and particularly purification were given top priority.[76] In the long run, however, the firm would prefer to make a hGH without the extra amino acid, and identical to the pituitary hGH.

Even at the end of 1980, the Swedish public environmental conditions for the technology still seemed shaky, implying risks and uncertainty for a firm investing in new technologies. In mid-1980, Kabi and KabiGen had gotten permits to work on a ten liter scale, but Kabi could not be sure whether they would be given a permit to grow the bacteria in large scale in Sweden. It was therefore uncertain whether they would eventually be able to reap economic benefits from the R&D investment.

Moreover, the contacts with Genentech functioned satisfactorily, but because both firms needed all the hGH they could get for pre-clinical and clinical tests and because the two developed marginally different production processes, Kabi needed an alternative source, which could produce hGH according to Kabi's specifications. This is why Hans Sievertsson and his boss Bengt Karlsson looked for alternative possibilities to grow the bacteria at the end of 1980. They found a willing partner in the English Department of Health, which owned the Centre for Applied Microbiological Research at Porton Down. Most importantly from Kabi's side, Porton Down had the localities to grow cultures and do experiments classified as high risk in large volumes. Reasons for English interest included that the Department had been actively encouraging Porton Down to be involved with such industrial applications, and moreover, that Kabi agreed to help the English authorities with their extraction of hGH from pituitary glands.[77] An agreement was signed in December 1980 that Porton Down would ferment the bacteria for hGH during a short period. The firm did not allow the Swedish regulations to stop technical developments.

As with the earlier fermentation work done with Genentech, the cell paste resulting from the hGH bacteria was flown from Porton Down to Kabi in Stockholm for purification, product recovery and analysis. In fact, the actions of the Swedish regulatory agencies was clearly pro-commercial in this case. They accepted that 10 liters of cell paste brought in from abroad was equivalent to the 10 liters of fermentation broth for which KabiGen had a permit. *Ten liters of fermentation broth* means ten liters of nutrients, liquid, variant cells with only a small portion of hGH. Cell paste is the concentrated remains of the fermentation process. For that reason, *ten liters of cell paste* corresponded to the approximately 400 liters of fermentation that Porton Down produced. The authorities' acceptance of this difference between permit and reality came from a desire to encourage industrial use of genetic engineering within Sweden.[78]

Moreover, the authorities may also have expected that the Swedish regulations would soon be revised to allow larger volumes and less stringent conditions, because Swedish agencies were expected to imitate American revisions. Kabi's first production tank was 1,500 liters.[79] So, although Kabi sometimes perceived the Swedish public environment as restrictive, Swedish regulations could be flexibly interpreted to promote industrial use of the technology.

In developing their industrial uses of genetic engineering, Kabi had influenced the development of public regulations along with external forces. By creating conditions which allowed them to pursue their industrial, technological trajectory, Kabi reduced uncertainty about their own future. Without legislative rules, unexpected and uncontrollable public or political opinion might again endanger their plans to realize the market and technical potentials of genetic engineering. With legislative rules, the firm could point to the specific activities which were allowed and could thereby make sure that their innovative activities and search process for a technical production system fell within the boundaries of the acceptable.

This consolidation of political conditions allowing industrial use of rDNA took some time but was not excessively slow: for Kabi to work on a 10 liter scale, it took 15 months from the date the initial GMAC permit was granted (when Kabi did not have labs) and only 7 months from their application under the new laws. Developing a functioning technical production system based on genetic engineering required physically bringing together and trying out the various steps. Because of that, not being able to carry out the work inside the company in Sweden was a handicap for Kabi. Initially, however, collaboration with Genentech was primary to find out about the bacteria. Cooperation with them worked well, not least because fermentation was done in South San Francisco, and product recovery and analysis in Stockholm.

However, because both Kabi's and Genentech's R&D projects were at their essence shaped by market forces rather than the knowledge forces internal to science, time was a vital factor. Anything which hindered Kabi from furthering the innovation process was viewed as an obstacle that required a solution. For example, in the case of cultivating the hGH bacteria, solutions could take the form of alternative production sites such as Porton Down to circumvent Swedish regulations. However, the Swedish authorities were aware of the pressures on Kabi and tried to find ways to facilitate industrial use of genetic engineering.

Kabi ultimately decided to produce in Sweden and faced many additional technical challenges to design a functioning production system. They gained Swedish approval for their brand-name Somatonorm, with an extra methionine in October 1985. This came several months after some batches of pituitary hGH purified much earlier were shown to be contaminated with a deadly virus. This prompted regulatory agencies in many countries to ban pituitary hGH, thereby opening wide the market for rDNA hGH. In 1987, Swedish government approval was given for Kabi's hGH without an extra methionine, named Genotropin. Human growth hormone has proven to be a very successful product for Kabi, now Pharmacia. In 1991, they sold 1.7 billion Swedish crowns ($243 million) internationally. The world-wide market was estimated to be $700 million that year, and is expanding.

If Kabi had decided not to, or had not found the resources, to switch to genetic engineering, they would likely have been kicked out of the international market in 1985. The expanded supply of hGH based on the recombinant DNA technique has led to a much larger market because many more children use hGH than was originally expected. Kabi's move to access and develop genetic engineering techniques for this particular industrial use has thus been successful. Because, however, this decision was taken early relative to contemporary basic science in molecular biology and relative to other firms, solving the technical problems required basic science as well as political negotiations.

6. Conclusion

The technological innovation process enabling Kabi to use genetic engineering to make human growth hormone was possible partly because individuals and organizations engineered politically as well as biologically. Development of the recombinant DNA technique in the early 1970s allowed scientists to engineer biologically. The techniques enabled the cutting and pasting of DNA, thereby promising control over nature, if scientists understood the biological functions. Initially, the practical techniques were difficult to perform and the more general knowledge lacking.

When these techniques were relatively unknown, it was some involved basic scientists who called for, and organized, regulation over certain types of genetic engineering experiments. Later, the drawing up of "blueprints" of political regulation involved a wider range of participants and public debate. This went hand-in-hand with experiments designed to answer scientific questions and to develop practical techniques. Many experiments were financed by public research funding, but some were financed by biotech firms and by established firms. Firms wished to direct development of the techniques so that they could be applied to specific industrial projects. The case which has been analyzed here pertains to Kabi's development of genetic engineering to make the pharmaceutical human growth hormone.

Before Kabi could actually integrate these new techniques into a production practise, however, many uncertainties needed to be reduced. Kabi, in interactions with others, worked to reduce the scientific, technical, economic and political uncertainties which faced them when management made the decision to move into genetic engineering in 1977/78. Working towards stablization of the technology and the environment was necessary to enable industrial use in a production system.

Scientific uncertainty was closely related to technical and economic uncertainty. Scientific uncertainty was partly focused on whether and how these new techniques would give new knowledge about the functioning of cells and DNA. For example, many thought these techniques should work and thereby force bacteria to produce foreign proteins like somatostatin and human growth hormone, but no one had proven this when Kabi became interested. "It seemed like science fiction".[80] Because addressing such scientific knowledge questions required functioning and relatively easy practical techniques, the interests and actions of scientists and firms overlapped. There were different organizational forms for their interactions. The one described here of scientists starting up biotech firms who in turn sold R&D contracts to established firms was a common form.

From the established firms' perspectives, however, scientific uncertainty was only part of the problem. They wanted to use these scientific developments to sell products in a market. Knowledge would have to be turned into reliable, cost-efficient techniques. This goal in turn necessitated the integration of these novel techniques into existing production practise. This led to new technological challenges which arose from the systemic, interlocking nature of the technical production system for the pharmaceutical. This technical production uncertainty was initially thought to be less than the scientific uncertainty because functioning techniques, knowledge and equipment already existed. As soon as the corporate R&D labs carried out experiments and tests, however, they were continually confronted with the question of how different the new technical system based on genetic engineering would be from the old.

This tie between scientific uncertainty and production technology uncertainty played a particularly interesting role in the relations between Genentech and Kabi. Genentech provided the molecular biology for the genetic engineering experiments, but Kabi provided production engineering and knowledge of the protein. Although there was a direct purchase of knowledge and techniques from California to Sweden, there was also initially mutual complementarity during joint cooperation. Each firm quickly tried to develop the other in-house.

Because this technology was intended to be translated into value through market sales, firms could not distinguish technical development from economic calculations and uncertainty. The firm had to believe costs could be recuperated and that solution of technical challenges would enable a reasonable selling price and profit. In addition to technical development, economic uncertainty was similarly related to financing of the necessary industrial R&D, particularly how to find enough money to finance expensive projects many years before that product was sold. In this case, the Swedish state played a vital role in financing and supporting Kabi's initial move into genetic engineering.

Prominent Kabi managers argue that if the state had not been there, the market would not have provided the necessary funds. It is a well known problem that the market has trouble evaluating risks and uncertainty involving new information and technology.[81] In that case, Kabi would not have been a leader into industrial use of genetic engineering.

The regulatory uncertainty in the earliest history of genetic engineering surrounded the technology itself. Scientists initiated regulation, and in Sweden as in the United States, regulation initially applied to university experiments, as they were the only ones doing them. Sweden, however, differed in that a wider range of representatives participated and in that the Pharmaceutical Manufacturers' Association (LIF) agreed early on to be represented in the scientific committee (GMAC) and to abide by their rules. Later, the debate became more public, with a wider range of views represented. Partly due to public and political pressures, the debates culminated in government regulation of the technology on January 1, 1980. Even the firms were for regulation, as this would set clearer guidelines defining paths of technical development that would be considered acceptable. The Swedish public debate subsequently died down for a time.

Scientific research and technical development in universities, in biotech firms, and in pharmaceutical firms thus reduced uncertainty about the technology and about environmental conditions. From the firms' perspective, reducing uncertainty meant developing functioning genetic engineering techniques and integrating those techniques into existing production practise. Industrial research and development activities were clearly contingental upon surrounding institutions such as public debate, government regulation, basic science and the market. Reduction of scientific, technical, economic and political uncertainty about genetic engineering came about through negotiations and interactions among various actors, both inside and outside of Sweden. This paper argues that reduction of uncertainty and stabilization of the technology and environmental conditions were necessary before firms like Kabi could develop specific, industrial use of this radically new technology.

Notes

[1]Department of Technology and Social Change (Tema T), Linköpings Universitet, S-591 93 Linköping
[2]*The New Collins Dictionary and Thesaurus* (1987).
[3]Although a distinction is made between the scientific techniques of genetic engineering and the biotech industry *per se*, the terms *genetic engineering* and *biotech* are here used synonymously, following common praxis in English. Genetic engineering refers to a set of techniques involving controlled changes to DNA while the term biotechnology refers to a broad category of biological processes, including beer and bread making. Despite this broad definition, the terms *biotech industry* and *modern biotechnology* refer to biological processes which are based on the scientific techniques of genetic engineering.
[4](Krimsky 1982)
[5](Kenney 1986)
[6](Teitelman 1989), (Orsenigo 1989)
[7]The following account about developments in Sweden is largely based on (Philipson 1977b). Åberg's participation is based on (Åberg 1982, 54).
[8]Reichard again approached the government, this time the Minister of Education Bertil Zachrisson, and suggested he appoint one or more members, but Zachrisson declined (Reichard 1993, 2). Zachrisson instead suggested that the Researchers-Parliamentarian Organization, RIFO, appoint someone.
[9]The committee members and the organization they represent are listed in (DsU 1978:11, Appendix 1, pp. 169-170).
[10](DsU 1978:11, appendix 1)
[11](Philipson 1977b, 60)
[12](Hamrin 1977, 23) (own translation)
[13](Åkerman 1977a, 4), (Wieslander 1977, 4), and (Åkerman 1977b).
[14]Quote from (Wieslander 1992) (own translation).
[15]The initial article in this series was Åkerman (1977c). Åkerman (1978, 2) (own translation) summed up his view of these technological developments with: "We must quite simply learn to say no to the so-called devil's doctrine which demands that all that can be done must be done". In polemic, Professor Philipson wrote "Instead of worrying ourselves and being afraid for that one does not understand, there are reasons to try to penetrate the questions in detail and to build an own opinion about what basic research is". He argued that one of the reasons there were so many misunderstandings in the debate about recombinant-DNA was that "journalists and the public have gathered their knowledge from utopic novels like Aldous Huxley's *Brave New World* and George Orwell's *1984*" (Philipson 1977a) (own translation).
[16](Pettersson 1992). Petterson and Philipson carried out the first experiment with recombinant DNA techniques in Sweden in 1975. It was by no means unusual for researchers to go abroad during periods of intense debate or uncertain and/or restrictive regulations. For example, a California research who did the main work in the Baxter-Goodman group on insulin did some experiments in France in 1978 (Dickson 1979, 495). Additionally, "Tiollais from Pasteur worked at SBL [Statens Biologiska Laboratorium] in Stockholm at one point when the opinion in Paris was negative to recombinant DNA work!" (Reichard 1993).
[17](Sievertsson 1992)
[18]However, Kabi's initial involvement with pituitary hGH was not quite as straight-forward as it may seem. In 1969/70, Kabi's top management almost decided not to develop pituitary hGH because several market surveys indicated that a pharmaceutical designed for 6-7 persons per million was uninteresting and unimportant as a product. The contemporary company directors seriously questioned whether Kabi should enter this market. As Åberg tells the continuation of this story: "Through the intervention of the then Minister of Industry, Krister Wickman, manufacturing of hGH continued, however, and today [1982] the hGH preparation Crescormon® is KabiVitrum concern's most profitable product". (Åberg 1982, 57). Åberg

continues by saying that Wickman personally wanted to see Kabi produce pharmaceuticals for more uncommon diseases. The reason Wickman had this influence then was that "Statsföretag" - literally, the state's companies, a holding company - had not yet been formed and Kabi's stock was handled by the Department of Industry (Åberg 1982, 57).

[19](Sievertsson 1992). Much later, secondary sources in Sweden indicate that Åberg heard about "synthetic" - i.e. recombinant DNA - insulin at a symposium (Norgren 1989, 78). However, the case of hGH shows that Kabi approached Genentech long before Genentech published anything on rDNA insulin (which was September 1978, about the time the final contract was signed). As Åberg was a highly public and visible person in this particular Swedish debate, many different interpretations of his actions have been published.

[20](Sievertsson 1992)

[21]In its technical sense, "ethical" means available only with a doctor's prescription. In 1990, Åberg claimed that hGH accounted for two-third of the profits of the whole company (Andersson 1990, 12).

22(Gonzalez 1979, 702). Raiti's statement was made in December 1979 at the symposium where Genentech announced their success in making hGH in bacteria.

[23]See further in (McKelvey 1994b).

[24](Laage-Hellman 1986, 59)

[25](Erhling and Ekengard 1980, 63)

[26](Åberg 1982, 55) (own translation). Despite the implication of Åberg's remarks - e.g. that Kabi acted even before Swedish academics had considered the industrial prospects, Fryklund argues that Åberg had a very wide network of contacts, and "although I don't know his thought processes at the time", Åberg undoubtedly contacted many experts who told him genetic engineering wasn't as far-fetched as it sounded at the time (Fryklund 1992).

[27](Fryklund 1992), (Fryklund 1993)

[28](*Uppsala Nya Tidning* 1977, 10)

[29](Cohn 1977, A9). Of course, unlike Genentech, Guillemin was not trying to develop a method to mass produce.

[30](Philipson 1977b, 68)

[31]See (McKelvey 1994a, chapter 5) for a discussion of the rivalry and cooperation between these two research groups.

[32](McKelvey 1994a), (Hall 1988)

[33](Sievertsson 1992)

[34](Åberg 1982, 59) (own translation)

[35]There was a serious fall-out between Åberg and Kabi in 1982, at which point Åberg left KabiGen to start his own biotech company, Scandigen. This new company, Skandigen, was heavily financed by the venture capitalist, Thomas Fischer. It was more a clearing house for genetic engineering, which made deals between firms and which supported research in general - rather than trying to develop own products. By 1982, Sievertsson had also left Kabi to move to Bofors; he returned to Kabi in the early 1990s.

[36](Sievertsson 1992)

[37](Fryklund 1993)

[38]Another reason that Kabi started KabiGen may have been to protect Kabi from a scandal or backlash against genetic engineering: if something dramatic happened, then it would be KabiGen which would be hurt, not Kabi. As mentioned earlier, a heated and critical public debate was then underway in Sweden.

[39]In January 1979, Statsföretag sold its 50% share of KabiGen to two companies in the Swedish Cardo business group, namely Sockerbolaget (literally, "sugar company") and Hilleshög (a plant development company) (Sievertsson 1992) (Brunius 1992a). These two companies were interested in using genetic engineering to improve plants, and thereby saw different technical and market potentials than the pharmaceutical potential envisioned by Kabi. Thus, another explanation for the formation of the separate firm KabiGen, instead of starting a

molecular biology department inside Kabi, was to make genetic engineering available to more Swedish firms than just Kabi. After all, Statsföretag and two established firms went in and helped finance KabiGen; surely they expected something out of the deal. Over the years, KabiGen's specific corporate strategy has oscillated between providing genetic engineering research and knowledge only to Kabi and providing it to Swedish industry in general. It has thus played several roles in relation to the introduction and use of this new technology in Sweden.

[40](Sievertsson 1992)

[41]Swanson at Genentech similarly relied on personal relations to obtain the very initial financing for Genentech from the venture capital company Kleiner and Perkins.

[42](Åberg 1982, 62) (own translation)

[43](Åberg and Sirvell 1978, 2) (own translation)

[44](DsU 1978:11). See also description of this investigation in a later official investigation (SOU 1992:82, chapter 3).

[45](Åberg 1982, 59) (own translation)

[46](Goeddel 1993)

[47] See (McKelvey 1994a, chapter 5).

[48](Holmström 1992), (Lin 1993)

[49]The permit was granted in (KNM 1980a, 2). (Sievertsson 1993) gives this explanation about why Kabi did not use the lab. At the time, Kabi and Genentech were using Genentech's facilities in California to ferment - i.e. grow - the bacteria.

[50](*Dagens Nyheter* 1979, 1, 11), (Ehrling 1979a, 2)

[51]There were only two articles by Ehrling and one by Hans Boman, Professor of Microbiology at Stockholm University - respectively, (Ehrling 1979a, 2) (Ehrling 1979b, 2) (Boman 1979, 2). Boman, with the approval of the University, had written a contract with KabiGen to enable university microbiologists to use the planned P3 lab.

[52]From 1932, the Social Democrats had been leading the government in Sweden, now and then in cooperation with one other party.

[53](Åberg and Sirvell 1979, 3) (own translation). Other relevant debate articles in this series include: (Holmqvist and Möllby 1979, 3), (Holmqvist 1979, 3), and (Ehrling 1979c, 3).

[54](Ehrling and Ekengard 1980, 68-69)

[55](LO/TCO 1982, 53)

[56]Wennergren's original proposal was criticized when respective government authorities and other parties received it for comments. Based on the account given in (SOU 1992:82, chapter 3), the following events occurred: After some revisions, the Ministry of Labor developed Proposition 1979/80:10 for the Swedish Parliament. The parliamentary working committee for these questions (socialutskottet) suggested the Parliament pass the proposition, but added that ethical, humanitarian and social questions about recombinant DNA in a longer term perspective should be investigated by a parliamentary committee. This eventually led to SOU 1984:88 *Genetisk integritet*. The Swedish parliament took the decision (Riksdagen 1979/90:107) on September 13, 1979, and on December 20th, the government gave four decrees to implement it.

[57](STU 1982, 6). Because the food division wanted to distribute a large sum of money, the decision had to go up to the STU board. In addition to approving the distribution of funds, the board also requested that the moral issues of genetic engineering be discussed, eventually leading to the book *Etik och Genteknik*, (STU 1982). Similar questions were being raised by the Swedish government in SOU 1984:88.

[58]Much later, Åberg thanked af Malborg for STU's early support in a public seminar on biotechnology (Rosén 1991). STU gave no support directly to Kabi or KabiGen. af Malmborg (1992) said in an interview that she did not know why Åberg had said that STU supported them.

[59]Sources include (af Malmborg 1992), (af Malmborg 1993), (STU 1979, section 5D). Many of these projects were handled by af Malmborg. Although a number of diverse projects were

supported, by far the largest grant went to Lennart Philipson, Microbiology, Biomedicinskt Centrum in Uppsala.
[60](Holmström 1992)
[61]See discussion in (McKelvey 1994a, chapter 3). Aharonowitz and Cohen (1981) make this argument about the similarity to previous engineeirng.
[62](Lin 1993)
[63](Åberg and Sirvell 1979, 3) (own translation)
[64](Fryklund 1993)
[65]The methionine, or met, gives a start signal for the translation of the gene. Genentech had no way of cutting it off after the met had fulfilled this function. Originally, the bacteria produced a mixture of met and met-less hGH, but when the fermentation method was under better control, the recombinant organisms only produced the met hGH (Fryklund 1993).
[66]This paragraph is based on interviews employees from the two firms.
[67](Andersson 1990, 12). Åberg also threatened to move production abroad in November 1979 if legislation was not passed soon (*Scrip* 1979, 3).
[68](Reichard 1993)
[69](Fryklund 1993)
[70]The decision was taken on December 20, 1979. Like the GMAC, the Delegation had a subcommittee for risk classification of experiments and held hearings to advise government decisions. See also (SOU 1992:82, pp. 53-57). After January 1, 1980, all work in Sweden with recombinant DNA techniques - whether in industry or universities - had to get permission from two government authorities, the Board on Working Environment (Arbetarskyddstyrelsen) and Public Health (Koncessionsnämnden för miljöskydd). In fact organizationally, the Delegation was placed under "Arbetarskyddstyrelsen", which is a ministerial body to make and enforce laws on working life. Gunnar Danielsson, the first chairman of the Delegation was also director-general for Arbetarskyddstyrelsen. "Koncessionsnämnden" sets the conditions for industrial activities by making and enforcing laws on environmental protection.
[71](Danielsson 1992) (own translation)
[72](Holmström 1994)
[73](KMN 1980a, 2)
[74]The application was sent to a number of potentially interested parties such as research councils, government ministeries and local Stockholm government bodies. The majority supported KabiGen's application, but stipulated that the application should be for specific projects, not general research using recombinant DNA (KMN 1980a, pp. 1, 5-7).
[75](KMN 1980a, 10). The board decided the application for recombinant DNA techniques was too general and therefore did not take a decision but instead allowed KabiGen to come in with a modified application before December 31, 1980. On December 9th, both KabiGen and KabiVitrum applied - KabiVitrum for permission to carry out development work with recombinant-DNA material and KabiGen to expand their permit to carry out research with recombinant DNA technology (KMN 1980a), (KMN 1980b), (KMN 1980c).
[76]It was also during this period when commercialization seemed possible that Genentech decided to produce hGH themselves.
[77](Walgate 1980, 528), (*Svensk Farmaceutisk Tidskrift* 1980, 623)
[78](Holmström 1992), (Brunius 1992b)
[79](Holmström 1994)
[80](Fhölenhag 1992)
[81](Arrow 1962)

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JONNY HJELM

Forest Work and Mechanization - Changes in Sweden and Canada during the Post-War Period

This article deals with workers' active introduction of technology into their labour process. Specifically, it is concerned with how forest workers, during the 1950s, gradually replaced the manual one-man crosscut saw with the motordriven chain saw. Why they did this and how the chain saw - together with other new mechanical devices - changed their working conditions are the two main questions addressed by this article.[1] It focuses on post-war developments within Swedish forestry.[2] I also make some comparisons of the mechanization process in Sweden and Canada (northern Ontario).[3]

Swedish historians of the labour process and of industrial change have often treated workers as passive - or even hostile - receivers of new techniques and methods of work.[4] This view can also be found in "traditional" studies of technical development in forestry, which is an industrial sector in Sweden that during the last forty to fifty years has experienced major technological changes. Usually, all that is mentioned is that the chain saw was introduced during the 1950s and that the new tool improved productivity.

My intention here is to analyze a technological change in which the workers' own views and actions were of central importance. At the same time, however, I place great emphasis on the economic and social structure in which they worked.

Technological transformation in Swedish forestry

Before mechanization, the Swedish forest worker felled trees, bucked them into suitable pieces, removed the branches and bark, and, with the help of a horse or some technical device, transported the timber from the cutting area to the nearest river. This work was performed during the winter primarily because timber transports required frozen, snow-covered ground. Afterwards - usually in spring but even during summer - the timber was floated down rivers to the forest industry on the coast.

In the cutting operation, the axe was originally the universal tool in all phases of work. The crosscut saw was introduced during the second part of the 19th century. It replaced the axe both in felling and in crosscutting operations. The crosscut saw had a handle at each end and was used by two men. During the first decades of the 20th century, it was replaced by the one-man crosscut saw. This saw had only one handle. The same decades also witnessed the appearance of the buck saw. It was mainly used for the felling of smaller trees. A new tool was also used for removing the bark from the bole of the tree; the so-called debarking spade replaced the axe. From this time onward, the forest worker used the axe only to remove branches from trees.

Until the 1940's the cutting operation was organized by a contractor, usually a farmer with a horse. He competed with other farmers to fell the timber and transport it to a drivable water course at the lowest price. An agreement was made between the forest contractor and the buyer or owner of the wood to settle the economic terms and the rules stipulating how the cutting operation should be done. The rules were rather detailed and breach of contract could be prosecuted. For example, it could be stipulated that the timber had to be delivered by a certain date and that the stumps were not allowed to be too high, which would mean loss of timber. In order to meet contract stipulations contractors employed and paid as many forest workers as were needed. Often the workers were relatives or neighbours of the contractors. Workers used their own tools, which they either bought for a relatively small amount of money in the village shop or made themselves. Because of this, there was considerable variation in tool design and efficiency.

The contract system meant that the real employers (the wood owners and buyers; for example, the large private forestry companies and the state company "Domänverket") were not directly involved in the organization of the cutting operation. As long as the tools and the methods of work did not violate the rules of the contract, the forest worker could freely choose how to work, what kind of tools to use, and also what time of day he wanted to work. The individual contractor was in charge of the cutting operation and had to ensure that it was done as stipulated.

During the 1930's and 1940's, conditions in Swedish forestry came under scrutiny. For example, it was questioned whether it really should be up to the workers to decide upon tools and methods of work. The critics wanted forest work to be analyzed in a scientific and systematic way. It is clear that many of those who discussed these views were influenced by the ideas of the "Scientific Management movement" which had it's real breakthrough in Sweden in the 1920's and 1930's. At the end of 1930's, Domänverket and the larger forestry companies in Norrland established two research institutes which began a systematic study of the different aspects of logging operations, including cutting. The main purpose was, at least initially, to give the employers information useful in wage negotiations. The need for this had grown especially as employers foresaw that the contractor system was soon to be abandoned. One reason for this, was the struggle of the Swedish Forest Workers Union (SSAF) against the contractor system, which had delayed unionization of the forest workers.

The initial unsuccessful efforts to organize forest workers were made at the beginning of the 20th century. A new nation-wide organization, the SSAF, was founded in 1918. This union grew slowly and did not aquire much prominence before the Second World War. At the beginning of the 1930s, SSAF had about 12,000-13,000 members, compared to approximately 150,000-250,000 workers employed in logging operations during the winter.[5] This was considered a low figure, especially compared to other industrial sectors in Sweden at that time, in which a large majority of workers usually were unionized. Another major problem and weakness with the SSAF was that it had not been able to negotiate a collective agreement with employers.

There were several reasons why SSAF grew slowly: (A) the contractor system, mentioned above, which made it difficult to see the features of the employee - employer relationship; (B) the lack of interest on the part of many workers who often saw themselves as independent farmers and not as wage earners (which of course had to do with the symbiosis between forestry and agriculture); (C) competition from other unions (especially the syndicalist union) and (D) the strong resistance against unions from the companies.

The situation for the SSAF changed dramatically during the 1940s. SSAF experienced something of a breakthrough in this period, negotiating it's first collective agreement and obtaining general recognition from larger employers. Another change during the decade, which the SSAF expected to have a positive outcome for the union and workers, was the first serious attempts to mechanize logging operations.

"Mechanization" becomes the key word

The forest companies' research institutes were not only concerned with producing work studies to be used in negotiations, they soon began to study the efficiency of tools, trying to find the best way to use these. Existing machines for motorized felling and cutting were also studied. Attempts to mechanize the heavy and time-demanding manual felling and crosscutting operations of forest work had been made since the latter part of the 19th century in the U.S.A., Germany and the Nordic countries. A variety of power sources, including people, steam and combustion engines, were unsuccessfully experimented with.

The first useful chain saw was constructed during the 1920s.[6] It was the so-called two-man chain saw, which however, was seldom used in Sweden. Instead, during the 1940s, it became clear that a reasonably-priced one-man chain saw was needed; that is, at a price that would make it possible for the worker to buy his own. Hitherto, and particularly in the case of the two-man chain saw, the high price had made such purchase impossible.

In 1948, 600 one-man chain saws were sold in Sweden. The number increased slowly until the middle of the 1950s, when sales figures suddenly increased. During the next 10 years 25000-30000 chain saws were sold per year (see Figure 1).

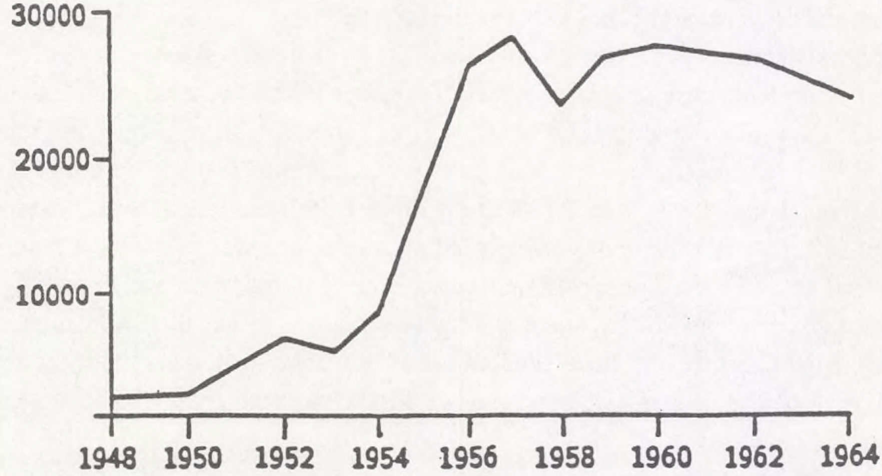

Figure 1. Sales of one-man chain saws in Sweden during the period 1948-1964. Source: Bo Helgeson, Jan Johansson & Ulf Lindberg, "Mendner i skogen. Några metodfunderingar kring motorsågens införande i den svenska skogsindustrin." (Mendner in the forest. Some thoughts about research methods concerning the introduction of the chain saw in Swedish forestry). *Nordiskt Forum*, No. 23.

Sales advertisements promised much. An advertisement from the mid-1950s stated "Now finally available - the new one-man chain saw which makes heavy work in the forest an easy game." But it was not only salesmen who described the chain saw in such lyrical terms. Similar opinions were formulated both by top managers in large-scale forestry companies and by persons within the SSAF. In short the one-man chain saw was expected to make forest work less taxing physically while providing forest workers with a higher income, but it was also expected to enhance or increase the well-being and social status of the latter.

The pioneers

The earliest versions of the new tool were the two-man chain saws. They were heavy, clumsy, and unreliable. Most of them were owned by the companies. Sometimes a few two-man saws were also loaned to the workers by the companies, at no or neglible cost. However, neither those who rented nor those who bought their own one-man chain saws during the early 1950's were entirely satisfied with these (no informant bought a two-man chain saw). Under normal circumstances, forest workers still preferred to use the one-man crosscut saw. The chain saws were used in felling and crosscutting, especially for larger diameter trees usually associated with older stands. In this type of forest work, the chain saws - when they functioned properly - could both lessen the physical strain and improve the income.

Forest workers who bought or rented these chain saws were "pioneers". One respondent, for example, told me: "I couldn't figure out what such a thing would look like, how it'd be constructed, that's for sure. How did they function? I read in the papers about them, I was eager to learn more about it... And then, when I saw one for the first time, I thought, Oh, it was damned simple...". The fact that a motor replaced muscle power was impressive, and it fostered great hopes. The most important source of information and knowledge about the chain saw at this stage was these pioneers, rather than salesmen or management. However, their predominately negative experience during the first part of the 1950s made most other forest workers somewhat sceptical about the chain saw.

Several of my respondents shared the opinion that the chain saw demonstrations in the early 50's, arranged by management alone or in cooperation with local salesmen, and the companies' (sometimes) relatively generous subsidization of the purchase by workers of chain saws was a strategy planned to capture the imagination of and accustom workers to the chain saw. Later, as workers began to "automatically" purchase them, management's interest and subsidization of the cost of chain saws decreased. Although there is no written source from the 1940's and 1950's which confirms my respondent' suspicions, a former director[7] of one of the largest forest companies in Sweden, Swedish Cellulose Co (SCA), corroborated in an interview that local management within SCA was encouraged (by the SCA headoffice) to try different means to speed up the mechanization process.

The breakthrough

In the middle ot the 1950's, the reputation of the chain saw slowly improved and more forest workers began to think about buying one. One reason for this change was persuasive advertising, but even more important was the fact that the chain saws had been significantly improved. McCulloch and Homelite models were referred to as "American saws". These had a carburator design that enabled the user to tip and turn the chain-saw in any direction when felling and bucking and were also usually equipped with the new and radically improved "Omark" saw chain.[8] These and other improvements slowly transformed the forest workers' initially negative evaluations into more positive ones. Respondents who during the breakthrough period bought and began to use the chain saw were clearly more pleased with their new tool than the pioneers had been.

However, not all forest workers had such positive experiences. There were still many who were disappointed with the chain saw, since their high expectations were not fulfilled. Their experiences differed mainly because of (a) the labor process which remained physically demanding so that methods of work had to be altered frequently; and (b) the individual piece-rate system.

Cutting operations demanded much and varied physical toil, in addition to a great deal of planning. It was important to be able to work flexibly and adapt quickly in response to the changing circumstances and terrain in which the work was carried out. The perception of difficulty and the ability to solve problems, as well as the manner in which these were solved, varied from worker to worker. How well any given worker handled such problems could be seen in his wage packet.

By buying a chain saw forest workers hoped to lessen the physical work load and improve their wages. Their expectations were met to a limited extent. Work operations where the chain saw first replaced the one-man crosscut saw

- the work of felling and bucking - were physically demanding. But since this comprised only about half of the total work and the chain saw was heavy to carry workers were just as tired after a day's work in the forest as before. Moreover, the time saved by using the chain saw wasn't used to rest and recover. Instead, workers moved as quickly as possible to the next work operation or tree.

These aspects of the process by which the chain saw was introduced into Swedish forestry were very often put forward by the respondents. They are confirmed by research results from more systematic attempts to evaluate the impact of the chain saw. These researchers[9] sometimes criticized the "optimistic" view. For example, at the Sixth World Forestry Congress in Madrid in 1966, Ulf Sundberg stated that "...the time which has been saved through this mechanization [during the last decades] has been filled in with other work elements which are just as heavy, from the physical point of view, as the one which was mechanized, which means that the total physical demand on the labor force over a work day or over a shift has remained the same".[10] At the same congress, the German researcher G. Kaminsky said that "The introduction of power saws has led to no direct physical relief. Carrying a power saw of 10 kg or more takes up the energy savings of the actual cutting work. The power saw should not be used continuously for more than one to two hours...".[11]

Many respondents believe that psychological stress increased with the introduction of the chain saw. The main cause of such stress was uncertainty about the chain saw reliability. Would it, for example, start in the morning and would it function the whole working day? It was not unusual for things to go wrong, and every involuntary break in work put the forest worker under pressure. "It was real hell when the saw chain or something else on the saw broke down, you know...we had a piece rate system which meant that you tried to catch up what you lost during the repair time". The technical problems decreased during the second part of the 1950's when the forest worker's own knowledge increased and when those who sold chain saws, as well as smaller motor repair shops, started to give quick and effective service.

Expections about wages were fulfilled to a greater extent by those who had bought a well-functioning chain saw and had the opportunity to use it in the type of forest where motorized felling was effective. Most respondents, however, said that their wages did not appear to change appreciably after they had begun to use the chain saw. Such a comparison was (and is) difficult to make since every comparison of piece wages has to relate to a number of factors that varied in each work place.[12] Consequently, forest workers had to evaluate their chain saw purchase with rather gross measures. The purchase was from an economic point of view either "good", "bad" or "so-so". It was almost impossible to be more exact. Because of these difficulties in evaluating the economic consequences of chain saw use hopes of increased income were perpetuated.

Forestry and farming[13]

Many of those in favor of rationalization of the labour process doubted that forest workers viewed such changes positively. Sometimes this was stated explicitly, but usually it was only insinuated that an alarming number of workers were traditionalists and preferred to work in the same way and with the same kind of tools as their forefathers.

However, the forest workers' background in small farming did not, as the rationalization spokesmen feared, slow up or hinder the technical development of forestry. Instead, this background (together with the piece-rate system and the characteristics of forest work) disposed them to take an active part in the transformation.

Perception of the chain saw was also affected by the general process of change in the countryside, which witnessed a trend from human/animal muscle-power based work towards an increased use of machines. Tractors, harvesters, cars, motorbikes, and electrical power for the household had improved living conditions in the countryside in the first half of the century. No one wanted, for example, to carry well-water to the house (often a woman's task) if water-pipes and an electric pump could be used instead, and no one wanted to travel 30 km by bicycle to soccer training in the evening (as some of my respondent reported having done) if a car or a motorbike could be used. Taking this into account, it isn't surprising that many forest workers had a relatively positive attitude towards new technology. The chain saw was thus seen as one more promising new technology which, together with other changes in the countryside, was expected to improve living conditions.

Individual actions and their consequences

Forest workers made the decision to purchase a chain saw only after having considered all the alternatives. Although they used every channel of information available, they never thought of using the union for this purpose.

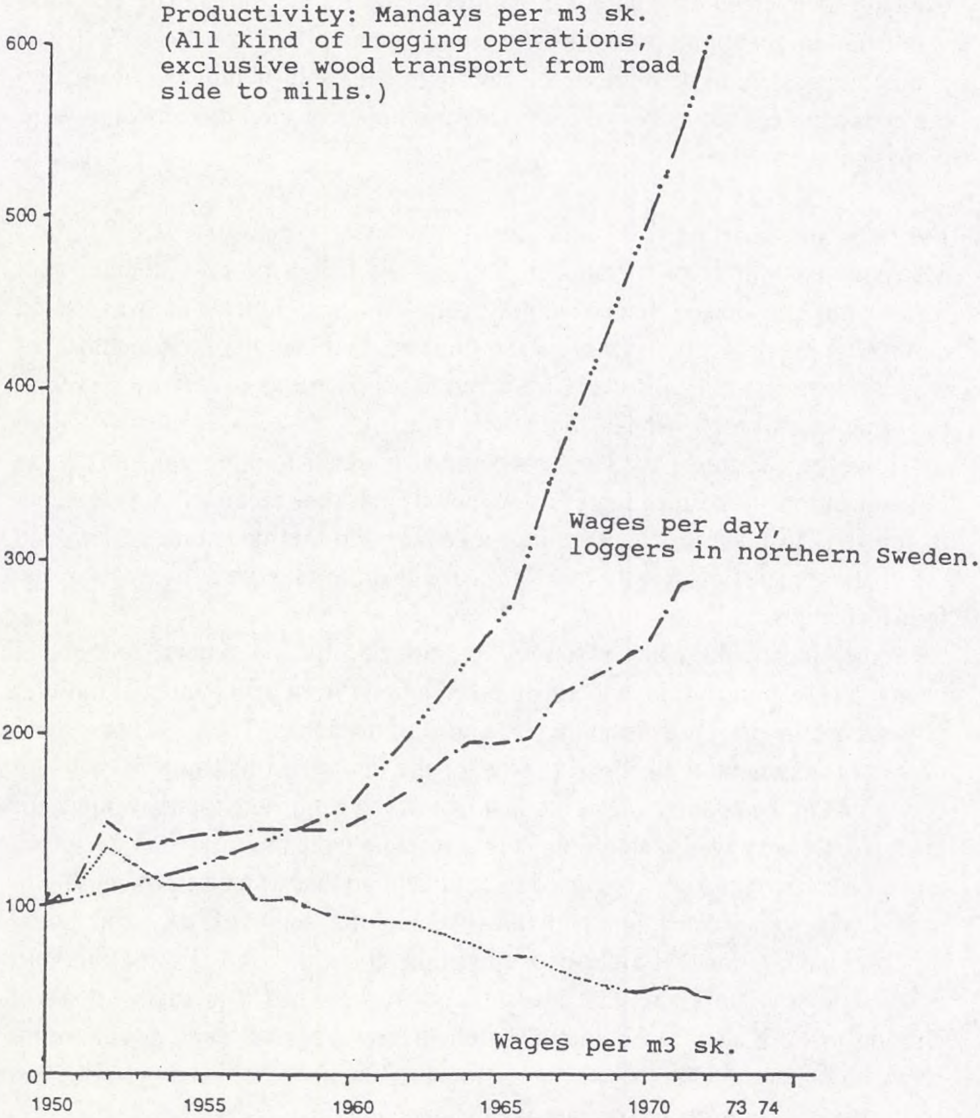

Figure 2. Key factors for the economic development of the forestry sector. Source: Einar Stridsberg & Leif Mattson, *Skogen genom tiderna* (A History of Forests), Stockholm 1980, p. 176.

They also never (or at least very seldom) asked themselves or the representatives of the SSAF what position they should take as a collective vis-a-vis the new tool or what possible consequences the new tool might have in the long run on employment, health, and the environment. The role of the SSAF was clear and went unquestioned: The union's task was to negotiate the best possible wage agreement, not to make decisions about the technology of production.

Unemployment had been virtually unheard of since the 1930's, but by the beginning of the 1960's, when (almost) all Swedish forest workers had obtained chain saws, unemployment slowly began to increase. The impact of mechanization on employment was difficult to evaluate because of specific conditions within forestry. One worker explained that: "...In the forestry sector the impact of rationalization isn't the same as in other sectors. In forestry one worker disappears here and another there, and two workers disappear there... This kind of change doesn't produce headlines in the newspapers".

Changes in the labor market also made local bargaining much tougher: "The employers became impossible to negotiate with, they didn't listen to our arguments any longer (as in the 1950s)". At the same time, the piece-rate system began to change. These transformations were difficult for forest workers to analyze because of the detailed nature of collective agreements. And what perhaps made analysis most difficult was that the changes coincided with and were in fact partly caused[14] by, other changes in cutting operations, such as the disappearence of manual debarking and the coming of tractors and skidders which decreased manual piling. Nonetheless, according to my respondents, and confirmed by statistics (see Figure 2), the new piece rate system often involved a decrease in wages per unit of production. Although wages followed (on average) the pace of other blue collar groups, they were maintained at relatively satisfactory levels only by increasing the tempo of work.[15]

The increased work tempo was most difficult to manage for older workers who during the 1960's comprised an increasing proportion of the total forest work force. Studies undertaken in Sweden in the 1960's and 1970's, show that the average age of forest workers was increasing. In 1959, 38 percent[16] were older than 40 years of age. By 1964, this figure was 58 percent. In 1972, the average age of forest workers was 45 years, which was 7 years older, for example, than workers in the engineering industry in Sweden.[17]

A well known fact in the forest industry is that the performance and age of workers are very closely related. Most workers over fifty had great difficulty keeping up with younger ones. Those above 55 years of age often produced only half as much as younger workers. Considering the effect of aging on wages is an important explanation of the growing dissatisfaction of Swedish forest workers during the 60's. Especially since these difficulties were experienced by many workers: by the mid 60's, 70 percent had ten years, or more, of forest work experience and near half of the labour force had twenty years, or more.[18]

The disappearence of manual debarking which occupied approximately 50% of the total time of cutting operations meant that workers now spent more time felling, delimbing, and bucking. In the middle of the 1960's they also began to use the chain saw when they delimbed (earlier this was done with the axe). The chain saw thus began to be used during almost every hour of the work day. At the same time, the work became more and more monotonous. This, together with the increased intensification of exposure to the chain saw caused an increase in accidents and injuries from long-term physical stress. In this way, the sense of well-being as well as work satisfaction deterioriated.

Forest workers gradually began to realize that as individuals their sphere of influence was limited. A proper decision and a rational choice might have different consequences if forest workers took the same course of action collectively.[19] From the individual's point of view, being a carrier of technology was not the only, or the best, way to improve working conditions. The individual's power resources were sufficient to become a carrier of technology, but not to achieve the main objective, which was a better income and a less burdensome job. Forest workers began to recognize the importance of the wage labour context of their use of the chain saw for the achievement of this main objective, and that in relations with employers collective behaviour and power were paramount.

The lesson that the forest workers learned, and which guided their actions when new machines were later introduced into forestry was the importance of acting collectively. For a labour force that was famous for it's individualism this was a new feature. Equally important, however, was the insight that good working conditions and wage increases are dependent not only on technology, but also on the social forms in which the technology is embedded. The piece-rate system increased the tempo of work and could turn all technological improvements into something that increased the rate of accidents. This was the reason why all 50 respondents were critical of what had happened over the last few decades. The time-rate system which the forest workers fought for during the 1960s and struck for in 1975 was acquired between 1975 and 1980. It has, however, been gradually undermined by declining real wages and the introduction of the so-called bonus system, a type of group piece-rate wage system. The machine operators have a specific entrepreneurial system which, like the piece-rate wage system, makes them work at the highest possible tempo and as long a workday as possible, often into the night.[20]

Technical developments in forestry have not, however, just changed labor processes and work conditions; there have also been significant repercussions in the respondents' social milieu. When the employment of forest workers changed from a seasonal to a yearly basis, farm closures and migration out of rural areas, already underway, were speeded up. The restructuring of both the farming and forest industries and the accompanying drop in the demand for workers changed the social milieu. The countryside of Västerbotten, which in the 1950's was full of life, is today sparsely populated. Travellers through the countryside today find deserted houses and abandoned farms and schools. That this would be the outcome of adopting chain saws and tractors in forestry, and of corresponding technical developments in farming, was something that very few forest workers foresaw during the 1950's.

A comparison between Sweden and Canada

The forestry sector in Canada has a greater output and employs more people than in Sweden. There is also greater variation of operations within Canadian forestry.[21] Therefore, in this paper I concentrate on northern Ontario, a region which in geographical terms is quite similar to northern Sweden.[22]

A full account of the difference between how forest workers in northern Sweden and northern Ontario experienced mechanization during the 60's and 70's, would of course have to include a deeper and more general comparison between the forestry sector in the two regions, and also a comparison of two regions' political and cultural conditions in the post-war period. This can not be done here. Instead, this comparison focuses on certain aspects of technological change and on how workers have experienced these.

The timing of and the preparation for the introduction of the chain saw

At the end of the First World War, when the forest industry experienced a labour shortage, the "...eastern Canadian woodland managers had formed the Woodland Section of the Canadian Pulp and Paper Association to pool information about production techniques and to examine new, mechanized methods".[23] However, such efforts were relatively modest, as was their outcome. The Second World War also witnessed a labour shortage in the forest industry, and just as the rationalization institutes did in Sweden, the Woodland Section intensified it's efforts to mechanize.[24] Forest companies' fear of suddenly having to face such a labour shortage (mainly due to the urbanization process) made them continue to work to increase mechanization after the war. In 1950 the Woodland Section formed a special Mechanization Committee with the purpose of further coordinating and concentrating the forest companies efforts to mechanize.[25]

The chain saw replaced the manual saws (usually the so called "swede-saw") a little earlier in northern Ontario than it did in northern Sweden. The chain saw was more common in the beginning of the 1950's, and the replacement process was also completed a little earlier.[26] One explanation may be that chain saws with an improved carburator design and the "Omark" saw chains were available to Canadian workers earlier than they were in Sweden. These chain saws, were difficult to purchase in Sweden in the beginning of the 1950s, and when they later became more common, they were more expensive than chain saws manufactured in Sweden, Norway and Germany.

But the importance of price[27] and technical advances should perhaps not be overestimated. Ontario bush workers seem to have been quite early chain saw users, even by Canadian standards. In Newfoundland, for example, the chain saw was introduced in 1954. Four years later, 87 percent of the workers used chain saws in their work. In other words, the timing and speed of the introduction in Newfoundland seems very similar to the diffusion process in Sweden.[28]

Most of the chain saws in Canada were bought by the forest workers themselves. The Canadian forest companies, like their Swedish counterparts, considered they did not have the financial resources to buy chain saws, and also thought the latter would be best cared for and used if the forest workers owned them.[29] Sometimes the companies helped the employees to finance their purchases, "...but it was the manufacturers and bushworkers themselves who were chiefly responsible for the widespread use of the chainsaw because they had the most to gain".[30] A study of mechanization in Newfoundland also stresses the importance of the activity of local salesmen while the companies generally seem to have been more passive here: "...[the chain saw] was introduced by the workers themselves without aid or incentive from the two paper companies and was, in fact, the only technological innovation to be so introduced."[31]

The largest forest workers' union in northern Ontario in this period - the Lumber and Saw Mill Workers Union (LSWU) - welcomed mechanization. "Throughout the entire post-war period, Lumber and Saw leaders gave enthusiastic support to woods mechanization. In 1948, on the eve of the introduction of substantial innovations, the union's *Ontario Timberworker* wondered about the technologically induced unemployment, but then proceeded to speculate: 'Mechanization will make for a better and greater production and will reduce the amount of heavy labour in industry'".[32]

This very positive attitude wasn't limited to Ontario and the LSWU. In Newfoundland, both the International Woodworkers of America (IWA) and the International Brotherhood of Carpenters and Joiners of America (IBCJA) looked forward to mechanization and thought it would improve working conditions while creating a year round forest worker. Such a worker, would not only have a safer, better paid and healthier employment, he would also be more willing to join the union and thereby contribute to the creation of a stronger union. One problem, however, was that many forest workers in Newfoundland (as in northern Sweden) during the 1950s and 1960s were occupational pluralists, and possibly wanted to stay that way.[33]

The purchase of chain saws by workers seems not to have been discussed any more critically or frequently by LSWU than by their Swedish counterparts SSAF. The union representative (IWA-Canada) Lloyd Szkaley, looking back to the 50s, says that there was "very, very little discussion. They [the chain saws] were brought in so smoothly".[34] This uncritical view seems also to have been shared by the workers. The speed of introduction of the chain saw and management's[35] apparent overall satisfaction with the way things worked out during this early phase of mechanization suggest that there hardly could have been any deep and general opposition on the part of workers.

This is also confirmed by the study about mechanization in Newfoundland forestry.[36] The introduction of the chain saw didn't meet any resistance (with the exception of a few cases, which had to do with "unique individual factors"). "No boy, I think that after about three years everyone in my camp had one. Of course some of them got it faster than the others but I don't think you could say anyone was against it. Some didn't get it because they didn't have the money to buy it right away. I think Uncle Max was about the last. He never did buy one himself but he used his young fellow's when he could get it because he was getting up (old) and it wouldn't pay him to buy one for just a short while".[37]

One of the following remarks by Curran, about Uncle Max' consideration of his age and remaining time as a (seasonally employed) forest worker is of interest here. "This [his consideration] indicates that there was a lot more rationality in the purchase of new items than one would at first suspect".[38] But there is no cause to be surprised to discover a rational attitude. This example, and many others in the study, shows that the attitudes and behaviour with regard to the chain saw were based on a rather complex - but individual - analysis of the eventual effects of chain saw use.

However, an interesting difference existed for some time between Sweden and northern Ontario. From the beginning of the 60's until the beginning of the 70's, three forest Companies supplied workers with chain saws (Great Lakes Paper, Ontario Minnesota Pulp and Paper, and Reed Paper). But this doesn't seem to have inspired other workers, or the LSWU, to try to force other companies to use the same free-tool system, and it was abandoned without major resistance from the forest workers or the union.[39]

The composition of the work force[40]

Forestry in Canada was for a long time an industry sector with strong seasonal features, employing workers on a seasonal basis. In the beginning of the 1940's, it was estimated that about 50 percent of the total labour force in Ontario was made up of farmers or farmworkers.[41] When the intensive farming season was over, the farmers and their farm workers sought employment in the forest. This exchange of labour suited the forestry sector, not only because the need for labour was greatest during the coldest half of the year, but also because "The skills required on the farm were to a large extent the same as those required in the woods. Skill with an axe and saw and the ability to drive a team of horses were essential in both. Special skills like those of the blacksmith and handyman, and even the amateur veterinarian, were of great value on both the farm and the forest scene."[42]

Apart from farmers and farm workers the labour force consisted of two other groups. One was a group of wage earners with regular seasonal unemployment. These were often newly arrived immigrants in so called unskilled and manual occupations. During the winter, when the demand for manual workers was low in many other sectors, these workers looked for employment in the forest. A third important group of workers consisted of so-called professional bushworkers. This group was distinguished in that forest work was the professionals' sole - or at least most important - source of income.[43]

The two last groups of forest workers seem to have made up a larger proportion of the total labour force compared to the situation in northern Sweden. Unfortunately, it is impossible to present figures to support this or analyze the differences in detail, because of the lack of relevant, or reliable, labour statistics in Canada as well as in Sweden.[44] However, the greater percentage of professionals and wage earners from different economic sectors within the forest labour force in northern Ontario, compared to that in northern Sweden, means that the ties between forestry and agriculture were weaker here.

One interesting similarity in the labour forces in Sweden and Ontario, is the workers' practice of "jumping" behavior. There is an important difference in that this behaviour seems to have been much more common, and practised over a much longer period, in Ontario.[45] Although the behaviour was widely discussed in Sweden, and condemned by many, it was mainly practised by a rather small proportion of the work force during the boom years in the late 1940's and the beginning of the 1950's. In Ontario, many workers, during the 20th century, seem to have been continuously on the move from one employer to another, searching for the employer that offered the best salaries and the best camp conditions. The economic trends within forestry had a strong determining impact on the outcome of this behaviour. This became particularly obvious during the depression in the 1930's. But during and after the Second World War, with the labour shortage, the jumping method functioned better. "Between 1943-4 and 1950-1 on average a bushworker in eastern Canada stayed at a job a mere 43.7 days, and the figure was decreasing sharply. One study showed that for every 100 men hired in the pulpwood sector, 'thirteen of the original 100 do not stay more than a week on the job, fifty do not complete one month's work".[46]

The labour shortage and the practice of jumping after the Second World War increased production costs in several ways. The Ontario companies' strategy to prevent this was: (A) improve conditions at the workplaces and in the camps, trying to give the workers a standard equal to other bluecollar groups[47]; (B) encourage immigration and thereby increase the proportion of immigrants within the labour force; (C) intensify the efforts to mechanize the logging operations.[48]

Companies in northern Ontario faced the same labour problems as their Swedish counterparts did after the war, and used the same methods to reduce the cost of production (in Sweden, however, the second strategy, the use of immigrants, mainly Finns and Poles, had relatively little impact on the labour situation). The long term effect of the different strategies described above, was - as in Sweden - the creation of a labour force, consisting of professional year round employed forest workers. In 1963, Gordon Godwin wrote in the journal *Forestry Chronicle* that "until about the mid-1950s the eastern pulp and paper industry placed almost total reliance on a work force that was busy farming from May until mid-September. Thereafter these men moved to the logging camps for the fall and winter. ...The sawlog industry, and perhaps in specific areas the pulpwood producers, may still depend in measure upon the man who is part farmer, part forest worker, but to increasing degree the man who works as a pulpwood logger is a specialist".[49]

The impact of chain saws and other technical devices on working conditions

Evaluation of the effects of mechanization on working conditions in forestry and of worker's perceptions of these changes is a complicated task, and the outcome depends to some extent on research methods, sources, and the time perspective. Statements from the 50's and 60's by union representatives, forest company management and technicians, and journalists touring work place sites must be treated carefully. Forest history, written by authors with connections to forest Companies, or those looking at technological change from a management point of view often constitute a problematic source for research. In Sweden, for example, the belief in the early 50's, widely expressed in journals and newspapers, that chain saws impacted very positively on work load and wages, was often based on a rather quick judgement after a demonstration or something similar, and then uncritically repeated by other journalists and commentators. Gross estimates of for example the percentage that production would increase and that physical demands would decrease as a result of chain saw use are often found in such sources.[50]

It does, nonetheless, seem that mechanization up to the beginning of the 80's has been better for forest workers in northern Ontario, who also have been more satisfied with the development than their Swedish counterparts. During interviews with forest workers in nortern Ontario,[51] I was told that mechanization generally has made forest work less physically taxing, while salaries have increased satisfactorily from year to year. And most important, especially compared to the situation with Swedish forest workers, the pace of the work is not felt to have increased compared with earlier periods.

Local union representatives in Thunder Bay, looking back on the 60's and 70's, shared the opinions of the interviewed workers. The same can be said about evaluations made by authors of forest history.[52] Summarizing the mechanization process (up to 1980) in northern Ontario, the historian Ian Radforth writes: "Loggers and their union expressed enthusiasm for most of the new machines and methods, not only because they were part of a North American culture that celebrated the triumphs of technology, but also because in the logging industry, mechanization appeared to bring higher wages, lighter, steadier work, and portable new skills".[53] James Wesley McNutt wrote in the end of the 70's that "The lumberjack has participated in, and has been the beneficiary of, this technological change, far beyond the average. Today he finds himself amongst the elite of the blue collar segment of our society".[54]

How can this more satisfying view among the forest workers, compared to forest workers in northern Sweden, be explained?[55] Several factors are important to understand the different experience of mechanization in Sweden and northern Ontario.

(A) *The labour market and the year round employment*. The labour market, which had an important impact on the Swedish forest workers' evaluation of mechanization, seems to have been experienced more positively by the workers in Ontario up to the end of the 70s: "The best you ever could think of", as one of the forest workers in Thunder Bay described it.[56] As a consequence, some forest workers continued to practice the old "jumping" behaviour, and moved between employers in search of the highest wages. They sometimes also moved to other industry sectors for this reason.[57] Although some workers behaved in this way, the trend was strongly toward a more stable labour force consisting of year round employees who, because of seniority clauses (achieved in 1955), preferred to stay with the same employer.[58] This professionalization process also means, of course, that the regular periodic unemployment decreased. This improvement was especially significant for the earlier "immigrant" and "professional" groups, which had faced the greatest problem finding work between logging seasons. They didn't have small farms or regular farm work which they could return to when the logging season ended. Because there was a comparatively larger percentage of the forest work force solely dependent on forestry in Ontario than in Sweden, technological changes that transformed seasonal work to year round employment was more greatly appreciated in the Ontario context. According to a former union representative in Thunder Bay, Eric Hautala, the connection between year round employment and mechanization was obvious to the workers.[59]

(B) *Average age and forest work experience*. The average age of the labour force in forestry in northern Ontario was probably lower than in Sweden. The long time experience of forest work and the aging forest workers' problem of maintaining work intensity was therefore not a problem for as many people as it was in Sweden. The relatively good labour market and the possibility of "jumping" probably meant that those who stayed in Ontario forestry industry were relatively satisfied with work conditions. These forest workers were either better suited for forest work than those who quit or their expectations realistically adjusted to fit the objective conditions in forestry.[60]

(C) *Chain saws, gas, oil and chain saw service*. We have seen that during the 60's three companies in northern Ontario provided their workers with chain saws, gas, and oil. Chain saw maintenance was an important issue for forest workers. The LSWU tried to address this concern at the bargaining table. The master collective agreement of 1955/56 between LSWU and the companies stated that the companies had to store parts for at least two chain saw brands and provide storage and repair sheds for the use of chain saw owners.[61] This made it easier for the workers in northern Ontario to use early chain saws which were prone to breakdowns. This kind of agreement didn't exist in Sweden in the 50's and 60's, neither were any forest companies supplying workers with chain saws. This was achieved in Sweden only in 1972, when all companies, after negotations with SSAF, agreed to supply their workers with free work tools.

(D) *Wages, pay differentials and wage systems.* From 1966 to 1975 the average annual wage for forest workers in Ontario increased 13.6% per year while the consumers price increased 7.3% per year. This was about the same average annual wage development as for Swedish forest workers during this period.[62] However, dissatisfaction among forest workers in Sweden grew during the 60's because the payment per unit produced declined. Complicated collective agreements and continuously changing piece-rate systems together with changes in logging methods made it difficult to evaluate new agreements and compare them with older agreements. In northern Ontario, the agreements were not as detailed, nor did local bargaining affect wages in the crucial manner they did in Sweden. Piece work wages in northern Ontario were mainly based on how many "cords" the workers (alone or together with others) produced. This relatively simple piece-rate system was not changed during the 50's, 60's or 70's. It was difficult for employers to decrease the payment per cord when in the 60's workers increased their production dramatically because of the chain saw. Since the introduction of the chain saw was carried out by the workers, they and the union reasoned that gains resulting from the new technology should go to the workers.[63]

In Sweden pay differentials within the forestry labour force were common and significant, and the gap didn't narrow during the 60's and the beginning of the 70's. This caused dissatisfaction among large groups within the labour force. According to Radforth, forest workers in northern Ontario wittnesed a contrary development: "...a major objective of the post-war labour movement - narrowing pay differentials - had been set".[64] This was partly caused by the trend from individual piece work to wages based on time rates. This in turn, had to do with technological change, which in northern Ontario followed a different track than it did in Sweden, in a way that affected work organization and the wage system.

To analyze this, it is important to understand how logging operations usually were carried out in northern Sweden and northern Ontario. During the 50's, 60's and 70's, the Swedish forest worker felled, delimbed (from about 1963-65 with the chain saw) and bucked the tree into suitable pieces. Up to the end of the 50's he also often debarked the logs. He would mark the logs with his personal mark, and then haul these together so the teamster, and from about the beginning of the 1960's, the driver of the tractor, could reach the logs and remove them from the cutting area. Logs were usually transported shortly after the cutter finnished his work. This method with it's obvious connection between performance and output, was readily suited to remuneration on an individual piece work basis.[65] This way of organizing logging is usually termed short-wood operation.

In northern Ontario, short-wood operations dominated until beginning of the 60's.[66] Usually the tree was felled, delimbed, bucked and piled in the woods during the autumn and the early winter by the individual forest worker, whereafter the teamster transported the logs to the landing between January and April ("cut-and-pile" method). A variation of this method was known as "cut-and-skid". Delimbed trees were skidded from the cutting area and afterwords bucked. In both "cut-and-pile" and "cut-and-skid" methods, the forest work usually was paid on an individual piece work basis. Although, with the latter method, if the teamster and the forest worker were not the same person, two persons cooperated and shared the piece-rate that was paid per cord.

The "cut-and-pile" method dissapeared when mechanized skidding became common of the beginning of the 60's.[67] The modernized "cut and skid" method, which now successively replaced other logging methods, usually involved two fellers and one skidder driver. The fellers cut (and sometimes delimbed) the trees, while the skidder collected the trees and hauled them to the road. Later, usually the same day, the fellers bucked the trees at the road. It was also common for team members to help each other, if one of them got into trouble or could not keep up the pace.[68] Usually team members had about the same work capacity.[69] If not, complaints from other members forced the low-producer to quit or move to another team. To avoid this kind of problem new teams and new team members had thirty days of training and adjustment on a time-rate basis.[70] If the new team or the new team member seemed to work out well the team thereafter was paid on a piece-rate or on time-rate basis with bonus. The team members equally shared a bonus or a payment based on how much they produced together.

But this was not the only difference between northern Ontario and northern Sweden. It seems to have been much more common in northern Ontario to remunerate forest work on a day-rate basis. For example, in 1967, the Spruce Falls Power and Paper Company paid about half of their labour force on a day-rate basis. Reed Paper also from time to time (mainly during the 60's) preferred to pay their workers on day-rate basis.[71] Other big forest companies, such as Great Lakes Paper, hired all their forest workers on a hourly basis.[72] The higher proportion of salaries paid on time- and day-rates, compared to Sweden, was the result mainly of technological change. Companies not only used tree length logging and the "cut and skid" method, but also used (or tried to use) to a much greater extent than the companies in Sweden different kinds of integrated, stationary or movable, machines in their logging operations. And the LSWU were able, through negotiation, to force almost every company to pay workers who drived - with the exception of skidder-drivers - machinery of this type on a time-rate basis.

The trend towards logging operations involving team work and a work force paid on a time-rate basis was seen by many as a welcome development. Many of those in the 40's and 50's in Canada (and Sweden), who speculated about the consequences of mechanization, especially union representatives, thought that mechanization automatically would increase the proportion of forest work remunerated on a time-rate basis. Expensive and complex machine-systems, would not only make it difficult to estimate individual input and output (and thus a "correct" salary), but would also create a need for more careful and skilled labour, the quality and not the quantity of which would be the central concern.

These different payment systems do not automatically produce an increase in wages. Neither do they guarantee less work intensity, safer work and more satisfied workers.[73] The important point is that work methods and wage systems, common in northern Ontario made it impossible or more difficult for the individual to maintain or raise his salary in order simply to make more money or to avoid or mitigate the consequences of unsuccessful bargaining. This opportunity existed in Sweden. As more and more forest workers chose, or felt forced, to speed up their pace of work, and as such efforts on their part were rewarded economically, it affected the following years' central wage negotiations between SSAF and the forest companies. The employers used average wage statistics from the previous year as undisputable proof of how much the workers could produce and earn (earnings which, for example, were compared to earlier periods and other blue collar groups). In this way, the (aging) workers in Sweden were trapped in a downward spiral.

* *

The mechanization processes in Sweden and Canada during the last ten to fifteen years exhibit more similarities than in earlier periods. One common feature is a strong trend towards an extended use of independent contractors.

In Sweden and Canada, forest ompanies have increased their use of contractors at the expense of employed workers.[74] In this way, forest companies seem to want the old contractor system back. The latter is similar to the system that was used in Sweden before the Second World War. It also means that the forest is harvested increasingly by individuals working under conditions similar to piece-work. In other words, piece-work, which for some time seemed to be on it's way out, appears to be making a come back in the forest industries of both countries.

A consequence of the increased use of contractors and also of mechanization in forestry is the threat to the existence of unions in Sweden and Canada. From the 1960's onward, membership has dropped dramatically in both Swedish and Canadian unions. In Sweden the following notice could be read in 1990 in one local newspaper: "THE FOREST WORKERS' UNIONS' EXISTENCE IS THREATENED. Mechanization in the forest industry during the last 30 years has decreased the number of forest workers from 58,000 to 12,500. The unions' future is right now under review".[75] A similar, but not quite as large, drop in membership in the LSWU forced the latter to merge with the IWA, in 1987. This decrease accelerated at the end of the 1980s. In Ontario, the membership in local 2693 of the IWA-Canada, which was about 7000 in 1988, decreased to about 3600 in 1991.[76]

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[1] In order to answer these questions I interwieved fifty elderly forest workers. They had worked in the forest in the county of Västerbotten in northern Sweden during the 1950s when chain saws superseded one-man crosscut saws. They had not only experienced the introduction of the chain saw but also the rapid technical changes of the last decades. Moreover, the majority had lived the greater part of their lives in an environment which was influenced not only by forestry development, but also by the transition from small-scale farming to large-scale mechanized production.

The first part of the interview was spent asking the forest workers about their life histories. In their youth and first half of their adulthood, many had one foot in a small farmer's society and the other foot, as wage earners, in the growing industrial society. However, when forestry and farming were rationalized, the base for small farming was slowly pulled out from under their feet. Some stayed in the countryside and became wage earners on an annual basis and some moved to industrial work in more densely populated areas. One facet of this development is the mechanization of forestry; in particular, the introduction of the chain saw. This meant that forest workers themselves took part in the process which in the end undermined their traditional small farming way of life. Therefore my research was not only concerned with technological development, but, in fact, was also probing into forest workers' collective history.

2 This part of the article is based on my thesis: Jonny Hjelm, Skogsarbetarna och Motorsågen. En studie av arbetsliv och teknisk förändring. (Forest workers and the Chain Saw. A study of Working Life and Technological Change), (Lund 1991). It contains a complete list of references.

3 I want to thank Thomas W. Dunk, Assistant Professor, Dept. of Sociology and Centre for Northern Studies, Lakehead University, for his editorial comments and also for valuable comments on the contents. Thanks also to Kaj Kangas for editing an early draft of the manuscript.

4 For a discussion of this aspect, see Hjelm 1991, p 11-15.

5 See Torvald Karlbom, Skogens arbetare ("Workers in the forest"), p 460-461, Stockholm 1968.

6 For a more detailed describtion of the innovationprocess, see Ulf Heinke, "Motorsågens utveckling. En teknikhistorisk studie av processen från innovation till normaltyp", Polhem 9:1 (1991), p 27-60.

7 Folke Heideken.

8 Ellis Lucia, "A lesson from nature: Joe Cox and his revolutionary saw chain", Journal of Forest History, July 1981.

9 See for example Greger Carpelan's (who worked at SDA) critical comments about the impact of the early chain saw on work load in his debate with Per Föjn in the two forest journals Skogen (1948 No 19 p 219-220, 1949 No 20 p 300-301, 1950 No 3* p 31-34*) and Skogsägaren (1950 No 8 p 167).

10 Ulf Sundberg, Proceedings of the Sixth World Forestry Congress, Vol 3, p 2743, (Madrid 1966).

11 G Kaminsky, Proceedings of the Sixth World Forestry Congress, Vol. 3, p 2976, (Madrid 1966).

12 The difficulties for forest workers who worked on piece work to calculate their wages was described in this way by the Finnish researcher Eino Saari in 1960: "Wages in forestry include some peculiarities. To a very large extent work is paid at piece rate. But these rates are often difficult to calculate fairly for the worker. Trees and tree species differ in size and shape; the terrain, the weather and the number of trees to be cut per acre vary, as, too, do marketing requirements, etc. Nowadays the wage rates are more often based on objective time and motion studies, but even so the systems are frequently complicated. Disputes may also occur between the worker and the employer's representative as to the measure and quality of timber cut". Eino Saari, "Social Progress for Forest Workers", in Proceedings of the Fifth World Forestry Congress, Vol 3, p 1876, (Seattle 1960).

13 For an interesting discussion of the symbiosis between forestry and farming - as an international phenomenon - see Eino Saari (1960) p 1873-1876.

14 New techniques such as skidders with wires and cranes and also debarking machines in the forest, or industrialized debarking at the

pulpmills fostered new piece-rate systems.

[15] See for example wage statistics from SSAF, Congress report 1987, Lönepolitik i Skogs (Wage politics within SSAF), (Gävle 1987) p 14-15.

[16] These statistics are based on workers who were employed by bigger companies.

[17] Hjelm (1991), p 163.

[18] Hjelm (1991), p 163.

[19] Philosophers have labelled such mechanisms counterfinality. A rational action with a definite goal produces the opposite outcome, see for example Jon Elster, Logic and Society: Contradictions and Possible Worlds, (New York 1978), pp 106-122.

[20] Ewa Liden, Skogsmaskinförarnas arbetssituation (The Forest Machine Owner's Work Situation), No. 178 from a series of reports from Institutionen för Skogsteknik, Sveriges Lantbruksuniversitet.

[21] See for example Åke Viksten, "Comparisons and Contrasts in the Practice of Forestry in Canada and Sweden", in Land, Life, Lumber, Leisure: Local and Global Concern in the Human Use of Woodland. An Interim Report. The report was prepared for an international workshop held at the University of Ottawa, 1991, eds. Anne Buttimer, John van Buren and Nancy Hudson-Rodd, (Ottawa 1991).

[22] The two geographical regions share many general similarities, see for example Geoffrey R. Weller, "Northern Studies in Sweden and Canada. An Ontario Perspective", Lakehead Centre for Northern Studies Research Report, No. 11 (1989).

[23] Ian Radforth, "Logging pulpwood in Northern Ontario", in On the Job. Confronting the labour process in Canada. Eds. Craig Heron and Robert Storey, (Kingston/Montreal 1986), p 259.

[24] James Wesley McNutt, "Labour Relations in the Forest - A half Century of Spectacular Progress", The Weyerhauser Lecture Series, The Faculty of Forestry and Landscape Architecture, University of Toronto, (Toronto 1978), p 18; Gordon Godwin, "The impact of modern technology on Forestry in Canada", The Forestry Chronicle, Vol. 39, March 1963, No. 1, p 449.

[25] Ian Radforth, Bushworkers and Bosses. Logging in Northern Ontario 1900-1980, (Toronto 1987), p 186.

[26] Radforth (1987), p 182

[27] Radforth (1987), p 182 and 256. The price was of course an important factor when the question of buying or not buying was up to the individual worker. In both countries, it took somewhere between 20 to 40 work days (depending on how expensive the chain was) for the "average" forest worker to earn enough to buy one. It's difficult to make a detailed comparison of chain saw prices in Canada and Sweden. One reason is the difference in kind and amount of subsidies that usually were offered when workers in Canada as well as in Sweden bought saws. Another reason

involves deficiences in wage statistics. However, a gross estimation, using chain saw prices and average piece rate salaries per day, indicates that the cost of chain saws were relatively similar in the two countries.

28 J.P. Curran, The process of Mechanization in the Forest industry of Newfoundland, MA-thesis Memorial University of Newfoundland (1971), p 72.

29 Radforth (1987), p 182

30 Radforth (1987), p 183.

31 Curran (1971), p 72.

32 Radforth (1987), p 221.

33 Curran (1971), p 145.

34 Interview with Wilf McIntyre and Lloyd Szkaley, union representatives (IAW-Canada, local 2693), 27/2 1992.

35 Radforth does not for example mention any complaints by management about workers refusing to buy the saw. My interviews with the forest workers also confirmed that workers didn't resist the introduction of the chain saw in the 50's.

36 The main purpose of his study was to see if there had been any resistance among forest workers in Newfoundland when new technology was introduced during the 1950's and 1960's.

37 Curran (1971), p 114.

38 Curran (1971), p 115.

39 McIntyre and Szkaley, interview.

40 The composition and features of the labour force are of course important in studies of workers' beliefs and behaviour during a period of rapid mechanization. The seasonal character of the forestry sector, it's symbiotic relation with agriculture, and how this influenced the forest workers in Sweden, were emphasized in my study. It has been estimated that more than 50 percent of the total working hours in Swedish forestry were done by seasonal workers prior to 1970.

41 Radforth (1987), p 30.

42 Wesley McNutt (1978), p 14.

43 But not all of the forest in Ontario was cut by wage earners. It was estimated that about 25 percent of the total harvest between the wars was done by settlers on their own woodlots or homesteads. Since about 50 percent of the total forest in Sweden was (and still is) owned by private owners (in the first half of this century often by active farmers), the share coming from farmers should have been greater.

44 Radforth (1987), p 115 and Hjelm (1991), p 135.

[45] This behaviour, and it's celebration by workers, was due in part to insecure employment conditions in the forestry sector, and seems also to have been part of the more general identity of forest workers in North America. See Matthew S. Carroll and Robert G. Lee, "Occupational Community and Identity Among Pacific Northwestern Loggers: Implications for Adapting to Economic Changes" in Robert G. Lee, Donald R. Field and William F. Burch, Jr, eds., Community and Forestry: Continuities in the Sociology of Natural Resources, (Boulder: Westview Press, 1990), 5; Thomas D. Dunk, The Environment in the Culture of Forest workers in Northwestern Ontario, a report prepared for the Canadian Paperworkers Union, Region Three (Dept. of Sociology and Centre for Northern Studies, Lakehead University, 1992).

[46] Radforth (1987), p 161. See also Wesley McNutt (1978), p 12-18 and, for a discussion of the labour force in forest industry in British Columbia, Patricia Marchak (1983), part 2 and 3.

[47] One result of efforts to improve conditions in Sweden was the disappearence of logging camps. This is reflected in my study, in the fact that very few of my informants had experienced logging camps. They worked relatively - compared to Canadian standards -near their homes, which together with the improved transportion possibilities made it possible for most of the workers to have a normal family life. One consequence was that those forest workers, who tried to combine forest work with farming, could also more readily help other family members with regular everyday farm work.
In Canada the development from camp to home life has been much slower. In 1945-46, 23471 employees in Canada were reported living in camps. Fifteen years later the number was reduced to 16411. Camp life in Ontario has not totally disappeared up to this day (as of the beginning of 1992, according to Wilf McIntyre and Lloyd Szkaley, one camp is still open). However, lodging standards have improved considerably since the early days.

[48] Radforth (1987), chapter 8.

[49] Godwin (1963), p 453.

[50] More reliable studies is for example work-life studies, done by sociologists, psychologists and other trained researchers. This kind of studies has been carried out in Sweden since the beginnning of the 60's, and is of course a useful source for historians.

[51] I want to thank the forest workers who participated in the interviews: Leo Legende, Gerald Pelletier, Daniel Letourneau, Bo Lundgren, Ulf Zackrison, Erik Brodin and Allan Boström. The interviews have been done over the course of my stay as a guest researcher at the Centre for Northern Studies at Lakehead University during the winter 1992. The stay was made possible by the financial support from The Swedish Institute and the Forestry-and Agriculture Research Council. I would also like to express my gratitude for the support I received from the Centre for Northern Studies. I benefitted, for example, from the use of an office, a computer and a coffee pot. I also want to thank Chris Southcott, at the Dept. of Sociology at Lakehead University, for arranging the interviews in Geraldton.

[52] This opinion was clearly expressed during the interview with the IWA-Canada (local 2693) representatives Wilf McIntyre and Lloyd Szkaley.

[53] Radforth (1987), p 236.

[54] Wesley McNutt (1978), p 8. See also Godwin (1963), p 450-452.

[55] A comparison between strike frequencies in Sweden and northern Ontario may indicate that forest workers in the latter region have been much more dissatisfied with their work conditions during the 60's and 70's. Strikes were more frequent in northern Ontario. They were usually about wages and fringe benefits. (See Douglas Thur, <u>Beat around the bush: The Lumber and Sawmill Workers Union and the new political economy of labour in Northern Ontario</u>, MA-thesis Lakehead University, 1990, appendix 1.) However, the connection between strike frequency and how workers experience their work is a complicated matter. Rather than indicating dissatisfaction, a high strike frequency can mean that workers and their union perceive that conditions are suitable for successfully using the strike to achieve certain goals. Moreover, correlations of strike frequencies and work satisfaction, especially when they deal with labour forces in two countries, also must consider how, for example, cultural and political patterns influence workers' behaviour and choice of strategies at the work place.

[56] Forest worker Ulf Zackrison, interviewed in Thunder Bay, 25/4 1992. See also Radforth (1987), p 229.

[57] Radforth (1987), p 229-230.

[58] Radforth (1987), p 225.

[59] Interview with the former LSWU representative, Eric Hautala, Thunder Bay, 2/4 1992.

[60] Information about the average age of the forest workers is from my interviews. Union representatives and forest workers, estimated that the average age of the workers was well below forty. However, interviews are of course not a reliable research method when dealing with this kind of problem. The average age of forest workers in Ontario, and the length of employment (indicating the frequences of the "jumping-behaviour" and how this may have affected their work experience), must therefore be studied in detail through the scrutiny of employment and union membership statistics, which I unfortunately haven't had the time or resources to do.

[61] Radforth (1987), p 204.

[62] Wesley McNutt (1978), p 21-23 and "Lönepolitik i Skogs" ("Wage politics within SSAF"), Congress report (in Swedish), p 14-15. The average annual wage increase between 1966 and 1975 for forest workers in Ontario is 13.6% percent and <u>not</u> 24% percent as Wesley McNutt wrongly states in his article (compare his statement with the figures in table 1. in his article).

[63] Radforth (1987), p 222; Hautala, McIntyre, Szkaley, interviews.

[64] Radforth (1987), p 222-223.

[65] It should be added that most of the workers preferred piece work, so long as wages kept at a satisfactory level, steadily improving from year to year without too much added stress.

[66] Thanks to John K. Naysmith and Crandall A. Benson, School of Forestry, Lakehead University. My discussions with them, together with information collected through the interviews with forest workers, made it easier for me to understand how logging operations in northern Ontario have been carried out during the post war period. Mr Benson also made valuable comments on the manuscript.

[67] Radforth (1987), p 206 ff.

[68] Interview with forest worker Ulf Zackrison, Thunder Bay 25/4 1992. See also Radforth (1987), p 208.

[69] This was stressed by several forest workers and also by Hautala.

[70] The trial period of thirty days was also the time of the test appointment, whereafter the worker had the same secure employment as other forest workers.

[71] Hautala and Szkaley, interviews.

[72] Radforth (1987), p 209.

[73] See for example Roger Ferragne, "The Quebec Woodlands labour market, in the past, present and future" in C.R. Silverside ed. Proceeding IUFRO Division 3. Forest Harvesting, Mechanization and Automation. Canadian Forestry Service Dept. of the Environment Ottawa, Ontario, Canada, (1974).

[74] See for example Douglas Thur, (1990), chapter six; Lumber Worker, (IAW-Canada union paper), vol 56 No. 5. This problem was also brought up in discussion by the IWA-Canada representatives Wilf McIntyre and Lloyd Szkaley. For a recently presented managent point of view, see "Boise Cascade tops 25 years in Canada", Canadian Forest Industries, January 1991.

[75] Hjelm (1991), p 188.

[76] McIntyre and Szkaley, interview.

THOMAS JORDAN

Dränkbara läns- och avloppspumpar – En fallstudie i branschutveckling[1]

En av efterkrigstidens internationellt sett mest framgångsrika innovationer inom pumpindustrin var Sixten Englessons dränkbara länspump, som introducerades på marknaden av Flygt 1948. Länspumparna följdes 1956 av dränkbara avloppspumpar, som med tiden kom att bli en ekonomiskt viktigare produkt för Flygt än länspumparna. Genom dessa innovationer utvecklades Flygt snabbt till ett mycket stort och starkt internationaliserat företag. De snabba marknadsframgångarna för Englessons innovation ledde till framväxten av en rad svenska (och senare utländska) tillverkare av dränkbara läns- och avloppspumpar. Den första efterföljaren kom 1952 (Ehlin), och ytterligare tre svenska företag började tillverka dränkbara länspumpar under 1950-talet. 1962 fanns det minst sju svenska tillverkare (Flygt, Weda, Kristensson & Grähs, Tornborg & Lundberg, Fischerverken, Solli-Generatorer och Vattentekniska Ingeniörsbyrån (Carlsson, 1962)), och ytterligare ett drygt tiotal i andra länder. 1994 fanns det fem svenska tillverkare: Flygt, Grindex (Flygt-ägt), Pumpex (ägt av Cardo Pump AB, f.d. Scanpump), Sala International (som tagit över Weda-pumparna), samt Weda Pool Cleaners. Flygt var utan jämförelse den största tillverkaren, med en koncernomsättning på omkring 4 mdr kr 1993, att jämföras med Grindex och Pumpex, som vardera omsatte omkring 80 milj. Den svenska pumpexporten består till mellan 2/3 och 3/4 av dränkbara pumpar, som alltså utgör en svensk specialitet inom den internationella tillverkningsindustrin.

Bakgrund

Begreppet "dränkbar pump" säger inte mycket om vari Englessons innovation bestod. Ett pumpaggregat består av dels ett pumphus med ett pumphjul, dels

[1] Artikeln baseras på ett kapitel i en kommande bok om den svenska pumpindustrins specialisering 1870-1990. Forskningen har finansierats genom generöst stöd från Humanistisk-Samhällsvetenskapliga Forskningsrådet, d.nr. F 122/93.

en drivenhet, t.ex. en elmotor eller en förbränningsmotor. Centrifugalpumpaggregat med pumphuset nedsänkt i vätskan har funnits sedan början av 1900-talet, bl.a. för att lösa problemen med att pumpa vatten från brunnar där uppfordringshöjden översteg 7-8 meter. Eftersom sughöjden i en pump är begränsad till ungefär denna höjd, måste vattnet tryckas upp om brunnen är djupare. Detta löste man genom att motorn placerades vid markytan, medan en lång axel gick ned till själva pumpen som placerades under vattenytan.

Pumpaggregat med dränkbara drivenheter (motorer) fanns också långt före Englessons länspump. Under första världskriget konstruerades i Tyskland vattenturbindrivna länspumpar som användes på krigsfartygen för att länsa undan det vatten som forsade in vid skador på skrovet. Dessa pumpar räddade ett flertal tyska krigsfartyg från att gå under (Lawaczeck, 1932, s. 182ff). Vattenturbinerna kopplades till fartygens brandvatten (d.v.s. till torrt uppställda pumpar). Sådana pumpar tillverkades även i Sverige av API och De Lavals Ångturbin under andra världskriget (intervju med Sven Björkander; De Lavals Ångturbin, 1956, s. 165ff). P.g.a. den låga verkningsgraden kom dock denna lösning inte att få en mer betydande spridning.

För vissa ändamål utgör ett dränkbart pumpaggregat med en inbyggd elmotor en idealisk lösning på en rad problem, framför allt vad gäller länspumpning av förorenat vatten vid byggarbetsplatser (se vidare nedan). Försök att utveckla sådana pumpar gjordes också redan kring sekelskiftet. Det stora problemet med dränkbara elmotorer är givetvis att den pumpade vätskan inte får komma i kontakt med strömförande delar av motorn. Antingen måste motorn isoleras, fr.a. vid axeln, så att den kan arbeta torrt utan risk för läckage in till motorlindningarna, eller också måste motorn arbeta i ett vätskefyllt motorrum, men då måste själva motorlindningarna skyddas från kontakt med vätskan. Två huvudtyper av sådana elmotorer utvecklades i Tyskland och USA under 1920- och 30-talen: spaltrörmotorer och motorer med gummibelagda eller plastade kopparlindningar med motorrummet fyllt med olja eller vatten. Dessa pumptyper hade dock en rad problem som medförde att de aldrig slog igenom som länspumpar. De var dyra att tillverka p.g.a. den komplicerade konstruktionen, de var känsliga för slitande vätskor, och de hade en jämförelsevis låg verkningsgrad. Däremot utvecklades tekniken för pumpning av dricksvatten i borrade djupbrunnar (över sju meters djup), där de nu är dominerande.

Det fanns en rad patent på olika typer av dränkbara pumpaggregat långt innan Englesson utvecklade sin länspump. Englessons innovation bestod alltså inte i *principen* av en pump med en dränkbar elmotor, utan i utvecklingen av en produkt som till rimliga kostnader löste en rad konkreta problem som ingen tidigare konstruktion kunnat lösa.[2]

Innovationen och utvecklingen inom Flygt[3]

Sixten Englessons bakgrund

Sixten Englesson studerade vid KTH och tog ut sin civilingenjörsexamen 1937. På grund av en rad olika omständigheter kom Englesson att utveckla ett osedvanligt brett och välvilligt kontaktnät, som senare spelade en väsentligt roll för Flygts framgångar. I början av 1938, kort efter examen, blev han av professorn i läran om vattenmotorer och pumpar, Hjalmar O. Dahl, erbjuden tjänst som försteassistent med uppgift att förestå laboratoriet. Englesson ledde de laborationer kring turbiner och pumpar som ingick i utbildningen för blivande väg- och vatteningenjörer, tekniska fysiker, skeppsbyggnads- och maskiningenjörer. Dessutom skötte Englesson laborationer och föreläsningar kring luftens termodynamik och kompressorer för blivande bergsingenjörer. Härigenom blev han personligen bekant med ett stort antal teknologer som senare kom att arbeta i olika typer av företag och statliga verk runt om i landet. Englesson var också under kriget ordförande i KTH's studentkår, trots att han redan tagit ut sin examen. I denna egenskap ägnade han mycket tid åt att etablera goda relationer till de militära myndigheterna, i syfte att undvika att teknologerna drabbades av inkallelseorder vid strategiska tidpunkter i deras utbildning. Detta bidrog ytterligare till att bygga ut Englessons kontaktnät, och (får man förmoda) gav upphov till en utbredd välvilja gentemot Englesson från teknologernas sida. Vidare var Sixten Englessons far, Elov, en känd person i ingenjörskretsar. Elov Englesson var chefskonstruktör vid Kristinehamns Mekaniska Werkstad (en del av Karlstads Mekaniska

[2] En viktig källa till hela artikeln är den opublicerade skriften *Pumpex 25 Years 68-93* av Stig Fisk, anställd vid Pumpex under många år. Fisk behandlar i skriften inte bara Pumpex historia, utan även övriga tillverkare i branschen.

[3] Uppgifterna i detta avsnitt baseras på en intervju med Sixten Englesson 22/9 1993, ett opublicerat manus av Sixten Englesson (1993), Ågren (1976), Forsgren & Larsson (1981) samt internt material från Flygt. Avsnittet har granskats av Sixten Englesson, som bidragit med värdefulla synpunkter och korrigeringar.

Werkstad) där han konstruerade bl.a. turbiner och en hydrauliskt ställbar propeller. Under denna verksamhet hade Elov E. samarbetat med Vattenfall om hundratals turbinleveranser, vilket innebar att namnet Englesson var väl känt på Vattenfall.

Vid laboratoriet för vattenmotorer och pumpar gjordes inte bara laborationer, man utförde också provningar av nykonstruerade pumpar på uppdrag av olika pumptillverkare. Englesson kom härigenom i kontakt med många olika konstruktioner, och utvecklade bl.a. ett väl fungerande samarbete med bröderna Stenberg i Lindås (som sedan 1930 tillverkade Flygts cirkulationspumpar efter Hjalmar O. Dahls konstruktioner).

När Flygts ende ingenjör gick i pension 1943 rekommenderade bröderna Stenberg Hilding Flygt att anställa Sixten Englesson i hans ställe, vilket skedde. Englesson framhåller själv att han under de första åren på Flygt gjorde många värdefulla erfarenheter, framför allt vad gäller vikten av väl fungerande reparations- och underhållsservice (Englesson, 1993, s. 6).

Innovationen

Impulsen till att utveckla en ny typ av länspump kom, som så ofta, från användarhåll. Hösten 1945 berättade en av Flygts försäljningsingenjörer, Folke Bjernér, för Englesson att en av hans bekanta inom byggnadsbranschen påpekat att det inte hade kommit några nyheter inom länspumpningsområdet de senaste tjugo åren, trots att länsningen av byggarbetsplatserna medförde en rad problem. Frågan ställdes om inte Flygt skulle kunna ta fram en bättre lösning.

De konventionella länspumparna (av centrifugal- eller diafragmatyp) måste placeras på en plattform ovanför det vatten som skulle pumpas bort, eftersom motorerna måste stå torrt uppställda. Då pumparnas sugförmåga är begränsad till ca 8 meter kunde sugslangarna inte vara hur långa som helst. Om arbetsdjupet ökade måste hela pumpaggregatet flyttas längre ned. De armerade sugslangarna och sugsilarna var tunga och otympliga, uppställning och flyttning av pumparna innebar mycket arbete, och hindrade annat arbete vid bygget. Pumparna gav ett relativt lågt tryck, vilket begränsade längden på de rör som skulle leda bort vattnet. Vattnet brukade i stället ledas bort i rännor, som ofta ställde till svårigheter för transporterna inom byggområdet. På vintern frös vattnet och bildade tjocka islager. Pumparna var också känsliga för onormala arbetsförhållanden. Om pumpens kapacitet översteg tillrinningen kunde det komma luft i systemet med följd att pumpen måste stoppas och vattenfyllas. Pumparna måste alltså övervakas, även på nätterna, vilket var mycket kostsamt. Om pumpen stannade p.g.a. elavbrott eller fel kunde vattnet stiga och motorn sättas ur funktion.

Folke Bjernér hade ett eget förslag till lösning som gick ut på att placera en vertikal motor på en flottör med pumpdelen nedsänkt under ytan. Flottören skulle följa vattenytan, och därmed eliminera en rad av problemen. Sixten Englessons far, Elov, hade lärt sin son vikten av att göra en mycket noggrann analys av alla inblandade tekniska problem vid nykonstruktioner. Englesson började med att beräkna och skissera ett pumpaggregat i linje med Bjernérs förslag. Det visade sig dock att aggregatet skulle bli tämligen otympligt, och därmed skulle flera av de grundläggande problemen kvarstå. Englesson började därför ingående analysera de krav som borde ställas på en länspump för att utveckla en ny lösning. Ett sådant projekt ingick dock inte i Englessons arbetsuppgifter på Flygt, som ju var ett företag specialiserat på värmeledningspumpar. Det nya projektet fick därför utföras på fritiden.

Analysen av länspumpningens problem gav upphov till följande lista på de krav en god lösning måste uppfylla:

> "1. Pumpaggregatet (PA) skulle vara lätt att flytta allteftersom grävnings-, resp. sprängningsarbetena fortskred på djupet.
> 2. PA skulle tåla att pumpa vatten innehållande slitande partiklar som sand och borrmjöl utan att dess kapacitet minskade alltför snabbt.
> 3. PA skulle tåla att översvämmas t.ex. vid strömavbrott.
> 4. PA skulle starta och pumpa omedelbart då strömavbrottet upphörde.
> 5. Om tillrinningen var mindre än PA´s fulla kapacitet skulle den kunna reducera sin kapacitet genom att "snörvla" en luft-vattenblandning.
> 6. PA skulle vara lätt och snabbt att serva så att dess tillgänglighet på arbetsplatsen blev maximal.
> 8. PA skulle ha så hög uppfordringshöjd att bortpumpningen ej skulle vålla svårigheter på arbetsplatsen.
> 9. Seriekopplingsmöjligheter för speciellt höga uppfordringshöjder kunde bli önskvärda." (Englesson, 1993, s. 10-11)

Englesson utgick ifrån att pumpen skulle drivas med en elmotor, samt att pumpen skulle kunna hanteras av en person. Med dessa utgångspunkter växte lösningen fram:

> "ett dränkbart pumpaggregat med vertikal axel, pumphjulet längst ner skyddat av en lämplig sugsil för effektiv "djupsugning" nära botten. Motorn måste för att ej gå varm om vattentillflödet upphörde vara utrustad med kullager och arbeta i ett avskilt luftfyllt motorrum, skyddat av en effektiv tätningsanordning runt axeln till pumphjulet på vattensidan. Denna tätning måste också tåla att pumpen går torr" (Englesson, 1993, s. 12a)

Englesson presenterade konceptet för Hilding Flygt på våren 1946. Hittills hade Flygt främst levererat pumpar till VVS-marknaden, där man hade en väl inarbetad försäljningsorganisation och ett gediget rykte. Englessons nya projekt skulle medföra att en stor satsning måste göras för att utveckla en ny marknad, med andra typer av kunder, som man inte hade någon tidigare erfarenhet av. Hilding Flygt var vid denna tid 81 år gammal, och inte benägen att ge sig in i nya krävande projekt. Englesson vände sig då till Tage Stenberg, till vilken han hade en god personlig relation, för att diskutera vilka möjligheter som fanns. Efter en grundlig analys av produktkonceptet och den potentiella marknaden kom Tage Stenberg fram till slutsatsen att Englessons projekt var värt att satsa på. Bröderna Stenberg räknade med att kunna köpa AB Flygts Pumpar när det löpande avtalet mellan företagen gick ut i juni 1947. Tage Stenberg ställde medel till Englessons förfogande att utveckla en prototyp på sin fritid, med löfte om att satsa på projektet när övertagandet av Flygts Pumpar var klart.

Det svåraste konstruktionsproblemet var axeltätningen. Några försök gjordes med manschettätningar av gummi, men denna lösning övergavs snabbt. En gynnsam omständighet i sammanhanget var möjligheterna att få tillgång till plantätningsteknologi. I Stockholm fanns en framstående konstruktör och tillverkare av mekaniska tätningar, Felix Huhn, ägare till företaget Gustav Huhn AB (efter ägarens far som drivit ett motsvarande företag i Berlin fram till 1940). Detta företag tillhörde pionjärerna i utvecklingen av mekaniska tätningar. Englesson etablerade ett samarbete med Huhn för att utveckla lämpliga tätningar till länspumpen. Den lösning som valdes innebar två plantätningar med ett mellanliggande oljefyllt rum. Till en början användes tätningsringar av kol, som dock senare byttes ut mot hårdmetall från Sandviken Coromant. Här kunde man åter dra nytta av att inhemska företag hade

en i internationell jämförelse framskjuten teknologisk position. Tätningarna utvecklades successivt, bl.a. med nya material och en utbytbar patron med bägge tätningarna sammanbyggda.
Konstruktionen var inte patenterbar i sina grundelement, eftersom den inte innebar nya tekniska principer, även om helhetskonceptet var revolutionerande. Detta innebar att fältet var öppet för potentiella konkurrenter att imitera Flygt-pumpen.

Marknadsintroduktion

En första prototyp var färdig för prov hösten 1947. Med hjälp av sina goda kontakter utverkade Englesson att Stockholms Gatukontor provade prototypen i sin verksamhet. Resultaten var positiva, varpå pumpen utsattes för det verkliga eldprovet. Under vintern 1947/48 provades länspumpen vid Vattenfalls kraftverksbygge i Harsprånget i övre Norrland. Resultaten var så övertygande att Vattenfalls styrelse ville köpa samtliga av de 20 första seriepumparna som Flygt beslutat att tillverka. Dessa pumpar tillverkades i lättmetall med gummibelagda slitdelar, utom pumphjulen som var av slitstarkt stål.

Den nya länspumpen möjliggjorde mycket stora besparingar hos många användare, eftersom den inte behövde dygnet-runtpassning. För vissa typer av anläggningsarbeten möjliggjorde den dränkbara länspumpen nya arbetsmetoder, särskilt vad gäller anläggningsarbeten djupt under marknivå. Englesson konstruerade en pumptyp särskilt för tunnelbanebyggena i Stockholm på 1950-talet, som fick en avsevärd betydelse för arbetsformerna, bl.a. kunde anläggningsarbetena utföras i betydligt snabbare takt än beräknat (Englesson, 1959, s. 679). Pumpen blev snabbt en mycket stor kommersiell framgång. Flygts Pumpar hade året före den dränkbara länspumpens introduktion (1947) en omsättning på drygt 2 milj. kr. 1956 var omsättningen uppe i över 11 milj., och 1965/66 passerades 100 milj. i omsättning.

Flygt under 1950- och 60-talen

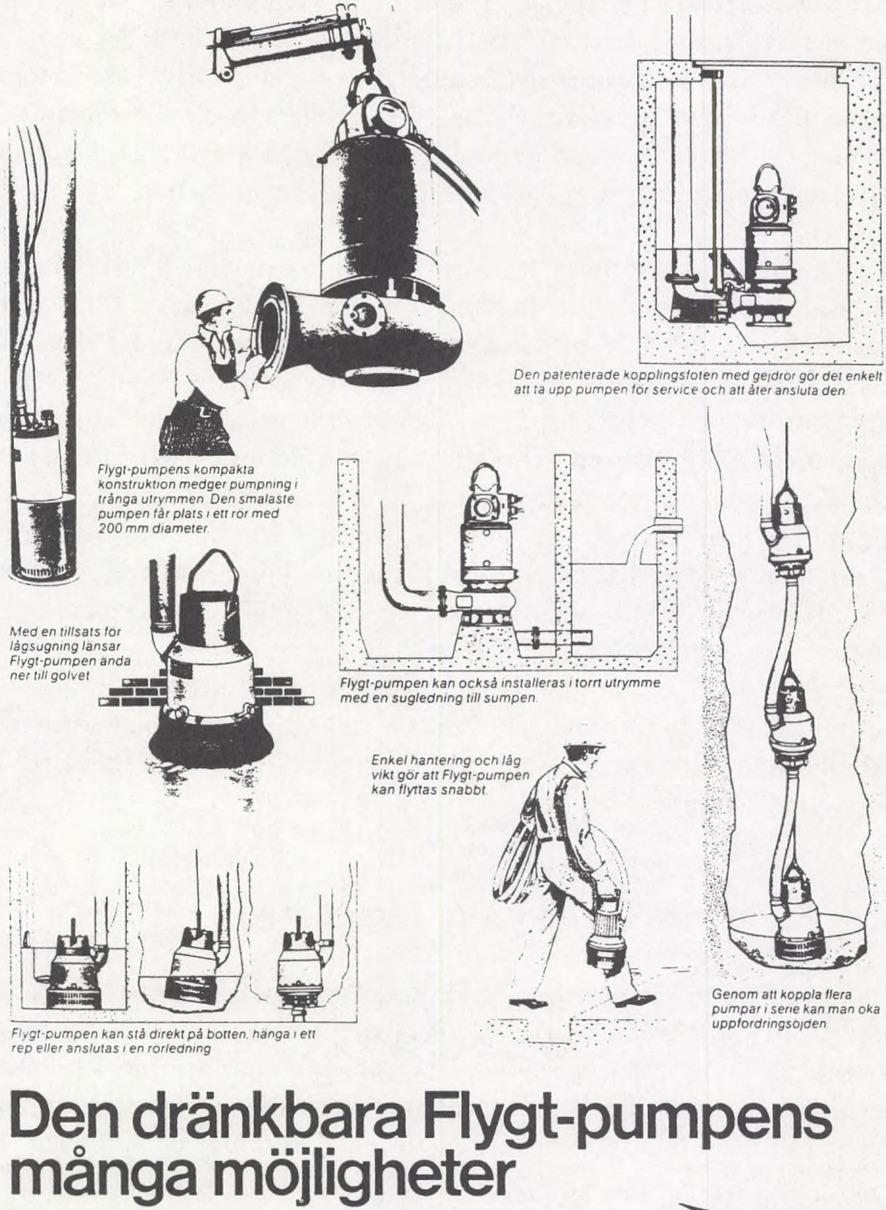
Volymmässigt gick de dränkbara pumparna om cirkulationspumparna, som tidigare var Flygts helt dominerande produkt, under 1950-talets sista år. Cirkulationspumparnas andel av omsättningen minskade sedan gradvis.

Det andra stora användningsområdet för dränkbara pumpar vid sidan av länspumpning är pumpning av avloppsvatten. Särskilda konstruktioner för detta lanserades av Flygt 1956. I samband med utvecklingen av dessa gjordes två innovationer. Den ena var en nivåvippa för automatisk start och stopp av pumparna som var billigare och betydligt mer driftsäker än tidigare konstruktioner. Nivåvippan patenterades, och såldes av Flygt även till konkurrerande företag. Den andra innovationen var ett automatiskt kopplingssystem för att förenkla anslutningen av de dränkbara pumparna nere i de avloppsvattenfyllda kamrarna. Detta kopplingssystem var patenterbart, och gav Flygt en mycket stark konkurrensfördel gentemot konkurrenterna tills patentet löpte ut i mitten av 1970-talet. Flygts avloppspumpar blev liksom länspumparna en stor kommersiell framgång, och konkurrerade så småningom ut de torrt uppställda pumparna. Flygt tog härigenom betydande marknadsandelar från de företag som traditionellt dominerat marknaden för avloppspumpar, framför allt De Lavals Ångturbin/Z&I, JMW och Elektroskandia. Trots en snabb ökning av försäljningen av dränkbara länspumpar under 1960- och 1970-talen gick avloppspumparna om länspumparna volymmässigt under början av 1970-talet. De dränkbara avloppspumparna är numera Flygts viktigaste produkt.[4]

Internationell expansion

Introduktionen av de dränkbara pumparna inledde en mycket snabb tillväxt för Stenberg-Flygt. Export i större skala inleddes tidigt. Den första stora exportmarknaden var England, där kolgruvorna fortfarande (sedan 1700-talet, se inledningskapitlet) hade problem med länshållningen. Ett engelskt företag som levererade maskiner för gruvindustrin, Midland Tunneling Co, blev agent för de dränkbara länspumparna 1952. Efterfrågan ökade snabbt på den engelska marknaden under 50-talet. För att kunna utnyttja den enorma marknadspotentialen krävdes en omfattande utbyggnad av försäljningsorganisationen på exportmarknaderna. Bröderna Stenberg prioriterade utbyggnaden av fabriken i Lindås, och var till en början tveksamma till att avsätta stora resurser till försäljningsorganisationen utomlands. De övertygades dock av systersonen Tor Albertson, som tidigt varit den inom Stenbergfamiljen som skött Flygts utlandskontakter, om nödvändigheten av en sådan satsning. Albertson blev sedermera vd för bolaget.

[4] Läns- och avloppspumparna har med tiden kompletterats med en rad andra produkttyper, bl.a. dränkbara omrörare och vattenturbiner.



Figur 1 Annons i *Pumphandboken*. Svensk pumpmarknad. Göteborg 1979.

1954 introducerades länspumpen i Japan, som snabbt blev en viktig exportmarknad. Avtal med återförsäljare i flera andra länder träffades under 50-talet. Med växande volymer ökade möjligheterna att bedriva utlandsförsäljningen genom egna försäljningsbolag, vilka etablerades flera europeiska länder samt i USA under slutet av 50-talet och början av 60-talet. I början av 1990-talet exporterades över 95% av Flygts svenska produktion.

Genom innovationens stora fördelar gentemot existerande produkter var marknadspotentialen världen över mycket stor. För att kunna finansiera en expansion som kunde exploatera marknadspotentialen krävdes dock stora kapitalresurser. Dessa blev tillgängliga genom att Stenberg-Flygt 1968 på Tor Albertsons initiativ såldes till ITT. Albertson såg också en fördel i att Flygt övergick från att vara ett familjeföretag till att ingå i en internationell koncern. Genom den nye ägaren kunde Flygt genomföra omfattande investeringar i fabriken i Lindås och fortsätta bygga ut försäljnings- och serviceorganisationen. ITT tillsatte styrelseordföranden i koncernbolaget, samt ställde hårda krav på Flygt-koncernens täckningsbidrag till ITT, men blandade sig i övrigt inte i företagets utveckling.

ITT Flygt har framgångsrikt försvarat sin ställning som marknadsledare på den globala marknaden. 1993 uppgick Flygt-koncernens omsättning till omkring 4 mdr. kronor.

Erik Ehlin och Tornborg & Lundberg[5]

Den dränkbara länspumpen hade en mycket stor marknadspotential, det stod klart på ett tidigt stadium. Det var bara en tidsfråga innan de första konkurrenterna skulle dyka upp. Flygt fick vara ensamma om innovationen ett par år innan andra tillverkare tog upp konkurrensen.[6] Den första konkurrenten kom dock aldrig att utvecklas till ett livskraftigt pumpföretag. Erik

[5] Avsnittet om Erik Ehlin och Tornborg & Lundberg bygger främst på en telefonintervju med Erik Ehlin 1/9 1993.

[6] I detta arbete diskuteras endast de inhemska konkurrenterna. Givetvis uppkom det även en rad konkurrenter i andra länder. En av de tidigaste var ABS (Tyskland), som började tillverka dränkbara pumpar 1959 (Informationsbroschyr från ABS). Carlsson (1962) uppger att det i början av 1960-talet fanns ett 20-tal tillverkare av dränkbara länspumpar i världen, varav sju svenska.

Ehlin, som arbetade med konstruktioner helt på egen hand i Kristinehamn, fick av en byggmästare förslaget att konstruera en dränkbar länspump. Byggmästaren ansåg att det fanns utrymme att förbättra Flygts pumpar, som i inledningsskedet var tämligen tunga, klumpiga och dyra. Ehlin besökte tunnelbanebyggena i Stockholm, och fick där tillfälle att se ett flertal dränkbara pumpar i drift. Ehlin besökte även Gatukontorets reparationsverkstäder, där en del av de tidiga Flygt-pumparnas svaga sidor blev uppenbara, bl.a. hade man problem med stenar som fastnade i silarna på insugssidan. Ehlin konstruerade då en betydligt lättare pump (ca 50 kg, jämfört med Flygts prototyp, som vägde ca 80), samt förbättrade en rad andra detaljer. Prov hos Gatukontoret visade att Ehlins pump hade en rad fördelar jämfört med Flygt-pumparna. Med början 1952 tillverkade Ehlin sina pumpar i liten skala under ett par år. Gatukontoret var dock ovilligt att ge en större order till Ehlin, som varken hade en mekanisk verkstad eller möjlighet till reservdelsförsörjning. Ehlin licensierade då sin konstruktion till grossistföretaget Tornborg & Lundberg, som levererade utrustning till gruvor och byggföretag (bl.a. även Salas godspumpar). Tornborg & Lundberg lät med början 1957/58 tillverka pumparna (under varumärket "Marinit") vid Gullbergs Mekaniska Verkstad, som låg intill Stenbergs i Lindås, där Flygts pumpar tillverkades. Gullbergs hade tidigare anknytning till branschen genom tillverkning av länspumpar för byggarbetsplatser av diafragmatyp. Det visade sig dock snart att Tornborg och Lundbergs marknadsorganisation inte lämpade sig för att sälja länspumpar. Normalt sålde man stora och dyra maskiner till byggföretagen, vilket innebar en mer förhandlingsinriktad organisation än som är lämpligt för sådana enkla produkter som länspumpar. Tillverkningen upphörde därför ett par år in på 1960-talet.

Fischer-Verken/Sundstrand/Pumpex[7]

Nästa konkurrent som uppträdde på scenen hade en liknande tillkomsthistoria, men utvecklades så småningom, om än på krokiga vägar, till Pumpex, en framgångsrik del av en mycket stor pumpkoncern. Pumpex är genom sin ägare Cardo Pump ett systerföretag till ABS, som i sin tur uppstått genom Scanpumps köp av och integration med det stora tyska pumpföretaget ABS. Liksom Grindex (se nedan) fungerar Pumpex som ett självständigt företag i

[7] Avsnittet om Fischer-Verken/Sundstrand/Pumpex bygger på Fisk, 1993, samt intervju med Ivan Eriksson 4/5 1993 och telefonintervjuer med Bo Ligner 6/6 och 9/6 1994.

förhållande till övriga delar av koncernen (trots att samma typer av pumpar tillverkas i ABS tyska del), med egen produktutveckling, tillverkning och försäljningsorganisation.

Fischerverken

Pumpex har en komplex bakgrund. En del av ursprunget utgörs av Fischer-Verken i Nordmaling. Detta företag grundades av Helmuth Fischer, en tysk som var officer under den tyska ockupationen av Norge. Vid krigsslutet deserterade han till Sverige med sin norska hustru och deras gemensamma barn. Han hamnade i Nordmaling och fick jobb på en fordonsverkstad. Så småningom startade han en egen bilverkstad. På landsbygden runt Nordmaling träffade Fischer på gödselvattenpumpar. Vid denna tid användes långaxliga vertikala pumpar. Fischer gjorde en egen konstruktion för detta ändamål, och började tillverka pumpar i början av 50-talet.

Genom utvecklingen av teknik för överföring av högspänning över långa distanser blev det attraktivt att exploatera Norrlands vattenkraft. Kraftverksbyggena hade ett stort behov av länspumpning, och Fischer lyckades sälja pumpar till ett par av dessa byggen. Just dessa kraftverksbyggen var bland de tidiga användarna av Flygts nya dränkbara länspumpar. Fischer anammade grundprinciperna, och konstruerade en egen dränkbar länspump, som började tillverkas 1955. Länspumparna kompletterades snart med dränkbara avloppspumpar.

Fischer tycks ha varit en begåvad konstruktör (om än med begränsad teoretisk kunskap), men mindre framgångsrik som marknadsförare och ekonom. Försök att marknadsföra pumparna via grossistföretag föll inte väl ut, och avsättningen begränsades till den regionala marknaden. Flygt och Weda visade sig vara alltför svåra konkurrenter vid kraftverksbyggena. Omkring 1965 var Fischers företag i svår kris.

Sundstrand

Efter ett mellanspel med oljebrännartillverkaren AB Tulifaverken som ägare togs Fischers företag 1968 över av Sundstrand Hydraulic i Huddinge. Sundstrands främsta produkt var kugghjulspumpar för oljebrännare, dessutom tillverkade man mindre cirkulationspumpar för centralvärmesystem. Sundstrand var en av Tulifaverkens viktiga leverantörer. Tulifas ägare visste att Sundstrand var ute efter att utöka sitt produktprogram, och inledde förhandlingar om ett övertagande. Fischer Pumpar AB såldes för en krona till Sundstrand. Sundstrand lade ut legotillverkning till fabriken i Nordmaling, och beslöt sig för att satsa ordentligt på att utveckla ett konkurrenskraftigt pumpprogram. Arne Jonsson, som var konstruktionschef på Weda rekryterades, och anställdes som utvecklingschef. Ytterligare en kompetent konstruktör rekryterades, Kjell Alfredsson från Sonessons Pumpindustri (f.d. AB Pumpindustri i Göteborg), en kollega till Arne Jonsson från en tidigare period. Dessa båda konstruktörer gjorde en omfattande revision av Fischers konstruktioner, samt utvecklade en rad nya produkter. För att sköta försäljningsorganisationen rekryterades en tredje erfaren person, Ivan Eriksson, även han från Weda.

Sundstrands ursprungliga strategi kom dock att överspelas av ytterligare ägarbyten. 1970 sålde styrelseordföranden i det svenska Sundstrandbolaget, Carl-Johan Bernadotte, sina aktier till moderbolaget, som därmed blev enda ägaren. Det amerikanska moderbolaget beslutade sig snabbt för att avyttra tillverkningen av dränkbara länspumpar. Enligt en version av orsakerna till detta beslut utsattes Sundstrand för påtryckningar av ITT, som några år tidigare förvärvat Flygt. ITT ska ha hotat Sundstrand med att ta upp tillverkning av oljebrännarpumpar om inte Sundstrand höll sig borta från de dränkbara pumparna. Budet gick först till Sonesson Pumpindustri, som kontaktades av Arne Jonsson som tidigare varit anställd där. Sonesson Pumpindustris vd., Sven G. Klemming, ansåg dock att man inte hade resurser nog att hantera detta marknadssegment, eftersom man hade händerna fulla med cellulosamarknaden. Ivan Eriksson, försäljningschefen, tog då kontakt med Pumpex, vilket ledde till att återstoden av pumpavdelningen togs över av Pumpex 1971.

Även den övriga tillverkningen i Sverige beslöts läggas ned. Produktionen av oljebrännarpumpar flyttades till Frankrike, medan cirkulationspumparna flyttades över till Storbritannien.

Pumpex

Pumpex hade startat några år tidigare (1968) som tillverkare av dränkbara länspumpar. Bakgrunden var Flygts köp av Kristenson & Grähs (sedermera Grindex) 1965. Försäljningschefen på Kristenson & Grähs, Gösta Hultman, hade farhågor kring Flygts framtida behandling av sitt nya dotterbolag, och började undersöka möjligheterna att starta ett nytt, fristående företag. Via Lions kände han Lars Berkle, som ägde ett elgrossistföretag, Elautomatik. Detta företag gjorde stora vinster, som till stor del gick bort i skatt. Berkle hade alltså riskvilligt kapital, medan Gösta Hultman hade marknadskännedomen. Pumpex Production AB bildades 1968 med ett begränsat aktiekapital. För att också tillföra det nya företaget tillverkningskompetens rekryterades verkstadschefen på Kristenson & Grähs, Malte Lövgren till Pumpex. Flygt var då i färd med att genomföra en grundlig genomgång av alla aspekter av Kristenson & Grähs. Lövgren befarade att denna genomgång gjordes för att förbereda en nedläggning och överföring av eventuella värdefulla erfarenheter till Flygt. Lövgren konstruerade hos Pumpex ett par typer av dränkbara länspumpar. I slutet av 1969 startades serietillverkning i Högdalen i Stockholm. Avsättningen skedde både i form av försäljning och i form av uthyrning. Redan de första åren inleddes exportverksamhet, med representanter i bl.a. Spanien, Jugoslavien och Tyskland.

När Ivan Eriksson från Sundstrand tog kontakt med Pumpex för ett eventuellt övertag av Fischer/Sundstrands dränkbara pumpar erbjöd sig en möjlighet att komplettera länspumparna med ett utvecklat program av avloppspumpar. Sundstrands program av dränkbara pumpar bestod 1971 huvudsakligen av avloppspumpar. En ny konstruktion av en dränkbar länspump var färdigutvecklad, men hade ännu inte tagits i produktion. När Pumpex övertog Nordmalingfabriken flyttades tillverkningen av länspumpar över dit från Stockholm.

Övertaget av Sundstrands avloppspumpar tillförde nya marknadskontakter, bl.a. i Tjeckoslovakien, Ungern och Bulgarien. Kontakterna i Tjeckoslovakien utnyttjades bl.a. för att köpa mycket billiga motorer till pumparna. Genom Black & Decker började man också sälja länspumpar i USA 1972, via B&D's försäljningsorganisation, och under deras varumärke. De sjunkande dollarkurserna i mitten på 70-talet medförde dock att samarbetet med B&D upphörde.

1974 sålde Pumpex ägare företaget till investmentbolaget Svenska AB Navigator, som ägde ett tjugotal företag i olika branscher, dock inget med anknytning till Pumpex verksamhet. Pumpex var kvar i Navigatorgruppen (som dock själv bytte ägare ett flertal gånger) ända till 1986, då Scanpump tog över. Det tycks inte ha funnits några fördelar för Pumpex med att ingå i ett heterogent konglomerat. Ansatser till flyttningar och omstruktureringar, samt byte av verkställande direktör i flera omgångar skapade osäkerhet och irritation, i stället för fokuserade satsningar under sakkunnig ledning. 1980 övertogs Navigatorgruppen av statliga Procordia. Efter ett flertal ägarskiften under 1985/86 bröts Pumpex ur Navigatorgruppen och såldes till Scanpump.

Ett par år före Scanpumps övertag fanns långtgående planer på en sammanslagning av Pumpex och Weda. Det nya företaget skulle enligt planerna ha en gemensam tillverkning och vd, men separata marknadsorganisationer. Planerna stannade dock på skrivbordet.

Scanpump hade via övertaget av JMW i Jönköping redan dränkbara avloppspumpar i sitt sortiment. Efter en utvärdering av de parallella linjerna kunde Pumpex komplettera sitt program med större avloppspumpar från f.d. JMW. Scanpumps köp av den tyska specialisten på dränkbara pumpar ABS 1989 reste frågan om Pumpex framtid. Efter utredning beslöts att Pumpex skulle fortsätta fungera som en fristående enhet, samt bli koncernens huvudleverantör av länspumpar. Detta innebär att Pumpex får leverera länspumpar till tyska ABS, vilket medför en avsevärt ökad marknad för Pumpex. En viss samordning av utveckling och tillverkning av främst motorer har genomförts mellan Pumpex och ABS.

Weda[8]

Weda hade ett helt annat ursprung än Flygt och Pumpex. Weda grundades 1934 av väg- och vattenbyggnadsingenjören W. Dan Bergman. Denne jobbade under 20-talet som vägbyggare i USA, och kom där i kontakt med en ny teknik för gjutning av magnesiumlegeringar. Återkommen till Sverige startade han ett lättmetallgjuteri i Södertälje. Detta gjuteri var det första magnesium-

8 Avsnittet om Weda bygger på intervju med Ivan Eriksson 4/5 1993, telefonintervjuer med Stig Hallerbäck 20/8, 1993 och 2/6 1994; Bo Qvarfordt 7/6 1994; Klas Lange 6/6 1994 och Eino Jelvegård 2/6 1994, brev från Erik Ehlin samt Fisk (1993).

gjuteriet i Sverige, men en stor del av produktionen utgjordes av aluminiumgjutgods. Bland de tidiga kunderna fanns protestillverkare, Volvo och SAAB. En av de viktigaste kunderna blev så småningom Bofors, som hade stort behov av lättmetalldelar.

Wedas tidiga erfarenheter av pumpmarknaden

Wedas första kontakt med pumpindustrin var tillverkning av gjutgodset till de hushållspumpar som AB Pumpteknik i Göteborg tillverkade i liten skala under andra världskriget.[9] I slutet av 1940-talet anlitades Weda av Hans Schröder AB, Lidingö, för att tillverka en ny typ av cirkulationspumpar för småhus på licens enligt ett patent av den schweizisk konstruktören Emil Lapp. Denna pump, "Mobila", var en liten cirkulationspump av "våt" typ där rotorn fungerade som pumphjul. Den såldes i betydande kvantiteter under 1950-talets början. Weda stod för tillverkningen, men var inte involverade i försäljningen.

Erfarenheten av att tillverka dränkbara pumpar kom genom att Flygt fr.o.m. de sista åren på 1940-talet anlitade Weda för att gjuta yttermantlar och motormantlar till sina dränkbara pumpar. Flygt blev en av Wedas största kunder, men ett par år in på 1950-talet blev Flygts försäljningsvolymer så stora att man beslöt starta ett eget aluminiumgjuteri i anslutning till Lindåsfabriken. Detta gjordes 1956, bl.a. genom att rekrytera Erik B. Lagergren från Weda. Det fanns även en annan länk mellan Weda och Flygt. John Logan, svärson till Wedas vd Sven Lind, var anställd vid Flygts försäljningsbolag i USA, vilket gav Wedas ledning tillgång till marknadskännedom inom länspumpområdet. Under en period göt Weda även pumphusen för Kristenson & Grähs, som inledde sin tillverkning av dränkbara länspumpar 1959.

Weda etablerar sig som pumptillverkare

När Weda förlorade leveranskontrakten med Flygt var man i behov av att hitta ersättningsprodukter. På en mässa i Stockholm 1954 hade man stött på Erik Ehlins dränkbara länspumpar (se ovan), som var utställda där. Dessa väckte intresse bland Wedas chefer, och samtal inleddes med Ehlin om ett

9 Källa: intervju med Lars Meyer, Pumpteknik AB, 8/2 1990.

eventuellt samarbete. Weda fick låna ett par av Ehlins pumpar för närmare studier. Något samarbete kom dock inte till stånd, utan Weda valde att göra egna konstruktioner. Då man saknade lämplig kompetens inom företaget rekryterades en konstruktör, Nils Grankvist (som inte tidigare arbetat med pumpar) för ändamålet. En första serie dränkbara länspumpar konstruerades och var färdiga för att introduceras på marknaden 1958. Vidareutvecklingen av Wedas länspumpprogram drevs av konstruktören Stig Hallerbäck, som anställdes 1959. Han hade tidigare arbetat som konstruktör av turbiner vid Nohab i Trollhättan, samt vid det mindre företaget Midbäck i Småland, som förutom reparationer och tillverkning av turbiner även byggde större invallningspumpar. Hallerbäck hade gjort ett antal uppfinningar som var intressanta för Weda, bl.a. vad gäller tätningar och möjligheter att byta hjul i pumparna, och kom att göra en rad innovationer under sin tid på Weda (som han dock lämnade redan 1966).

Flygt hade genom sitt försprång i tiden etablerat en stark ställning på marknaden, särskilt inom byggsektorn. Weda sökte därför möjligheter att finna egna nischer. Den mest särpräglade produkten blev ett aggregat för bassängrening vars kärna utgjordes av en modifierad dränkbar pump. Bassängrenare tillverkades inte av någon av de övriga svenska tillverkarna av dränkbara länspumpar, vilket gav Weda en relativt skyddad specialitet. Bassängrenarna kom med tiden att utgöra ca. hälften av omsättningen på pumpar. Genom vissa konstruktionsdetaljer som skilde Wedas länspumpar från Flygts (t.ex. inbyggd flottör och startapparat) kunde Weda vinna order även inom byggsektorn.

Wedas export av pumpar kom igång tidigt, framför allt p.g.a. möjligheterna att utnyttja Bofors utbyggda försäljningsnät. Wedas chef Bengt Kjellander kom från Bofors, och var dessutom släkt med Boforsledningen. Detta var en stor tillgång, då han kunde förmå Bofors utländska försäljningskontor att ta sig an marknadsföringen av Wedas pumpar. Vid Bofors dotterbolag i Italien startades t.o.m. en sammansättningsfabrik för länspumpar. Exporten kom, liksom hos övriga länspumptillverkare, att dominera pumpförsäljningen.

Identitet och ägarförhållanden

Wedas ursprung som lättmetallgjuteri präglade under lång tid företagets in-riktning. Den grundläggande identiteten som ett gjuteri innebar att man inte på ett självklart sätt satsade på utveckling och marknadsföring av färdigvaror. Vid 1960-talets mitt utgjorde pumpförsäljningen omkring 1/4 av Wedas omsättning, som alltså dominerades av legotillverkning av lättmetallgjutgods. När Hallerbäck utvecklade konstruktioner som innebar övergång till andra material, som rostfritt stål och plast, föll detta inte i god jord, eftersom man såg pumparna som en avsättningsmarknad för lättmetallgjutgodset. Bofors köp av Weda 1940 påverkade dock företaget i riktning mot förädling av gjuteriprodukterna till halvfabrikat och komponenter genom att en ny chef, Kjellander (se ovan), med erfarenhet av försäljning av färdigvaror tillsattes.

Weda var mycket starkt beroende av försvarets beställningar under 1950- och 60-talen, ca. 90% av omsättningen i början på 1960-talet genererades av försvarets materielinköp. Under 1950-talet var detta en mycket gynnsam marknad med goda marginaler. Under 1960-talets första hälft minskade dock denna marknad drastiskt, vilket medförde att Weda gjorde betydande förluster. Under samma period fanns betydande motsättningar inom företagets ledning. Dessa inre problem innebar bl.a. att utvecklingen av pumpmarknaden blockerades under en period då marknaden för dränkbara pumpar utvecklades snabbt. När Stig Hallerbäck lämnade Weda 1966 rekryterades Arne Jonson från AB Pumpindustri för att bli chef för både konstruktion och produktion av Wedas pumpar.

Bofors minskade behov av lättmetallgods medförde att Weda 1968 såldes till Svenska Metallverken, en del av Grängeskoncernen. Försäljningssamarbetet på exportmarknaderna fortsatte dock. Under 1980-talets första år fanns långt framskridna planer på en fusion av Weda och Pumpex (se nedan). Enligt planerna skulle tillverkningen koncentreras till Pumpex fabrik i Nordmaling, men man skulle behålla separata marknadsorganisationer. Av dessa planer blev det dock inget.

1984 bildades Componentagruppen, där Weda Pump ingick som en av flera delar. Componentagruppen köptes i sin tur 1991 av Svedala Industri, där Trelleborg var en av huvudägarna. Svedala såg möjligheter att genomföra strukturrationaliseringar inom Componenta-gruppen, bl.a. avseende Weda Pump. Weda Pump omsatte 1991 drygt 40 milj. kr. fördelade på två ungefär lika stora produktområden, dels de vanliga dränkbara länspumparna, dels bassängrenare. Länspumparna flyttades över till Sala International, som sedan tidigare hade en pumpavdelning som tillverkade och marknadsförde sligpumpar. Bassängrenarna passade dock inte in i denna struktur, utan köptes ut av två anställda vid Weda, Helge Schaumann och Klas Lange, som bildade företaget Weda Pool Cleaner AB. När Stanco (se nedan) åter gick i konkurs 1993 köptes pumpprogrammet upp av Weda Pool Cleaner AB, som alltså etablerade sig som konkurrent till de Wedapumpar som förts över till Sala International.

Kristenson & Grähs/Grindex[10]

Grindex, som sedan 1965 är ett dotterbolag till Flygt, etablerade sig som tillverkare av dränkbara länspumpar 1959. Ursprunget till Grindex låg dock i en helt annan bransch, nämligen tillverkning av bildelar. Företaget Kristenson & Grähs etablerades 1939, och drev under de första tjugo åren huvudsakligen tillverkning i liten skala av olika typer av bromsar, samt slipmaskiner för verkstäder och bergborrar. Företaget startades som en ingenjörsfirma av två nyutexaminerade ingenjörer från KTH. Grähs avled redan 1945, medan Börje Kristenson ledde företaget ända till 1966. Under de första åren arbetade firman med militära produkter, som t.ex. trampminor och ammunition. Kristenson hade kontakter med ett engelsk företag som tillverkade bromsutrustning. När kriget satte stopp för importen av reservdelar till motorfordon började Kristenson & Grähs åta sig renovering av bromssystem och tillverkning av bl.a. packningar till bromssystem. Efter kriget kom denna verksamhet att utvidgas och företagets viktigaste produkter blev bromsar av olika slag. Senare tog man även upp tillverkning av slipmaskiner (därav varunamnet Grindex).

Kristenson & Grähs blir länspumptillverkare

Kristenson kände Sixten Englesson väl från studietiden vid KTH, och var god vän med Torsten E., bror till Sixten. I sin bekantskapskrets hade Kristenson även en konstruktör på Flygt, som hade idéer kring konstruktioner av länspumpar som han diskuterade med Kristenson. Genom dessa kanaler konkre-

10 Avsnittet om Grindex bygger på intervjuer med Göran Holmén 24/4 1989 och Björn Callin 21/2 1990, telefonintervju med Erik Eriksson 1/6 1994, samt Fisk (1993) och Tidning för Byggnadskonst, 1965:9.

tiserades idén att ta upp tillverkning av dränkbara länspumpar. Flygts pumpar studerades, och man diskuterade deras svaga sidor med användare. Som ett resultat av detta valde man att använda ett hölje av korrugerat varm-galvaniserat stål i stället för aluminiumgjutgods. Detta gav en mycket hög stötsäkerhet. Flygts första länspumpserier var relativt tunga, till följd av att man byggde in en väl tilltagen marginal vad gällde motorkapaciteter. Genom att använda mindre motorer kunde vikten reduceras, men man ökade samtidigt risken för överhettning vid överbelastningar. Kristenson utvecklade därför ett ventilsystem som automatiskt öppnades när pumpen gick torr. Detta system patenterades.

Efter att ha löst ett antal konstruktionsproblem i de första prototyperna introducerade Kristenson dränkbara länspumpar i företagets verksamhet 1959. Vid denna tid var omsättningen vid företaget under 2 milj. kr per år. Även om företaget inte hade någon tidigare erfarenhet av pumpmarknaden fanns det vissa kontakter och erfarenheter att bygga på. Slipmaskinerna till bergborrar såldes nämligen till bl.a. gruvor och vägbyggen, som samtidigt utgjorde länspumparnas viktigaste marknader. Försäljningschefen Gösta Hultman hade därför redan ett relativt omfattande nätverk av personliga kontakter att bygga på när de dränkbara länspumparna introducerades. Omsättningen på länspumparna ökade snabbt. I mitten av 1960-talet tillverkades ca 3.000 pumpar per år, omsättningen uppgick till 4-5 milj. kr, varav över hälften härrörde från export. Kristenson & Grähs hade då etablerat sig som en erkänd leverantör på marknaden (Tidn. f. Byggnadskonst, 1965:9, s. 427-34).

Ägarbyte 1965

1965 köptes Kristenson & Grähs av Flygt, som vid denna tid var ca. 20 gånger större räknat i omsättning. Kristenson lämnade posten som vd, men kvarstod under en period som konsult. Som ny vd tillsattes Bertil T. Nilsson (som senare var Flygts vd under många år). Företagets namn ändrades till Grindex, för att vara mer gångbart på den internationella marknaden. Vilka avsikter Flygt hade med förvärvet går inte att utröna i efterhand, men då Grindex var lönsamt fick man fortsätta fungera som en fristående enhet inom Flygtkoncernen.

I samband med övertaget inledde Flygt en omfattande genomgång av Grindex verksamhet. Detta skapade oro bland personalen, man befarade att Flygt skulle mjölka ur all värdefull information för att sedan lägga ned företaget. I detta läge lämnade försäljningschefen Gösta Hultman och verkstadschefen Malte Lövgren företaget för att i stället bygga upp den nystartade konkurrenten Pumpex.

Tillverkningen av bromsar upphörde kring 1970, medan man fortsatte tillverka slipmaskiner fram till ca 1980. Större delen av Grindex pumpar används på byggarbetsplatser, medan gruvindustrin utgör en annan betydande marknad.

Andra tidiga tillverkare av dränkbara länspumpar

Förutom de ovan nämnda tidiga efterföljarna till Flygt förekom ytterligare två fabrikat på marknaden under början av 1960-talet, *Vattentekniska Ingenjörsbyrån* och *Solli-Generatorer*, båda med tillverkning i liten skala i Stockholm (Carlsson, 1962). Båda dessa fabrikat försvann snabbt från marknaden, sannolikt p.g.a. en kombination av otillräcklig kvalitet, bristande servicemöjligheter och otillräcklig skala på tillverkningen. Tyvärr har det inte varit möjligt att klarlägga hur dessa företags pumpar konstruerades och tillverkades.

Vadstena Mekaniska Verkstad övervägde i mitten av 1950-talet att ta upp konkurrensen med Flygts dränkbara länspumpar. Vadstena var Sveriges tredje största tillverkare av pumpar för VVS-system, efter Flygt och AB Pumpindustri. I och med Flygts utveckling av de nya länspumparna kunde företaget erbjuda ett fullt program till byggsektorn, d.v.s. både länspumpar och pumpar till VVS-systemen. Vadstena befarade att det skulle vara ett handikapp i konkurrensen att bara kunna erbjuda VVS-pumpar. Planerna kom så långt att konstruktionsarbete inleddes och en prototyp tillverkades och provkördes. Man beslutade sig dock för att lägga ned projektet därför att vare sig länspumpar eller avloppspumpar passade in i Vadstenas försäljningsorganisation, som var inriktad på VVS-sektorn.[11]

Under 1960-talets andra hälft försökte sig *Norrköpings Mekaniska Verkstad* på att etablera sig som tillverkare av dränkbara länspumpar. Tidigare hade

[11] Telefonintervju med Lars Hultman 1/6 1994, tidigare vd för Vadstena Pumpar.

man främst utfört legoarbeten, och man sökte efter lämpliga produkter att producera och sälja i egen regi. En egen variant utvecklades och såldes i mindre kvantiteter (bl.a. på export) från ca. 1964, men tillverkningen nådde inte lönsamhet. Pumparna var relativt tunga, och man kunde inte erbjuda lika höga servicenivåer som Flygt och Weda med sina utbyggda nätverk. Tillverkningen lades därför ned ca. 1969.[12]

SPV/Stanco[13]

Stanco, som var Sveriges minsta tillverkare av dränkbara länspumpar under 1970- och 80-talen, är i stort sett okänt på den svenska marknaden. Över 95% av produktionen exporterades, främst till USA. Ursprunget till Stanco var verktygstillverkaren SPV, Svenska Precisionsverktyg. Detta företag var under 60-talet främst en underleverantör till Volvo Flygmotor. När försvaret minskade på beställningarna av militär utrustning för att i stället tillverka i egen regi sökte SPV efter alternativa produkter. Man fick kontakt med Taxnäs Mekaniska Verkstad, som hade ett patent på en anordning för automatisk nivåreglering till pumpar. Företaget hade då tillverkat ett mindre antal pumpar med nivåreglering. SPV köpte konstruktionen och viss utrustning. Konstruktören Lars Sjögren rekryterades från Flygt för att vidareutveckla en dränkbar pump med nivåreglering. SPV hade tidigare ingen erfarenhet av denna marknad, utan fick anställa säljare för att bygga upp försäljning i Sverige och utomlands.

En serie av dränkbara länspumpar konstruerades och introducerades på marknaden i slutet av 1960-talet. I slutet på 70-talet köptes SPV av Linden-Alimak i Skellefteå, som ville komplettera sin tillverkning av gruvutrustning och byggkranar med fler produkter. Tanken var att utnyttja det kundnät man hade för att sälja många olika typer av utrustning. Det visade sig dock att det kontaktnät man hade byggt upp inte var relevant för en bärkraftig försäljning av länspumpar. Endast i USA utvecklades försäljningen positivt. Där såldes pumparna av Stanco, ett företag som specialiserat sig på lättare utrustning. På 80-talet köptes Linden-Alimak av Stanco, men det svenska företaget hade stora ekonomiska problem. SPV delades upp och såldes. Pumpdelen hade tre

12 Uppgifter om Norrköpings Mekaniska Verkstad härrör från en telefonintervju med Gunnar Östergren 7/4 1994.

13 Avsnittet om Stanco bygger på telefonintervju med Kurt Modig 17/8 1993.

anställda, som köpte ut verksamheten 1982 och startade ett fristående företag. Namnet SPV fick inte användas, varför man valde att kalla sig Stanco, som var ett inarbetat namn i USA. Affärskonceptet byggde på att Stanco skulle utveckla och sälja pumpar, men låta legotillverkare står för tillverkning av delar och montering. Efter en tid beslöt man att ta över slutmonteringen själv, och etablerade en monteringsverkstad i Vikmanshyttan. Strukturförändringar hos den amerikanska agenten ledde dock till att det amerikanska bolaget minskade sin lagerhållning, vilket under ett år kraftigt minskade Stancos intäkter. I samband med denna kris diskuterades inom Pumpex ett eventuellt förvärv av Stanco, men denna affär blev inte av. Inkomstbortfallet i kombination med kostnaderna för etableringen i Vikmanshyttan ledde till företagets konkurs 1990. Konkursboet såldes till en ny ägare i Lidköping som drev verksamheten vidare ett par år. Stanco gick dock åter i konkurs 1993, och pumpprogammet såldes till Weda Pool Cleaner AB (se ovan).

Stancos pumpar ansågs av flera utomstående bedömare vara av hög kvalitet. Stanco utvecklade också ett program av explosionssäkra pumpar som fick stor användning i USA's kolgruvor. Detta är dock en marknad med mycket stora efterfrågevariationer, vilket är svårt att klara för ett litet och starkt specialiserat företag. Stanco tillverkade i slutet av 80-talet ca 1000 pumpar per år, och hade en omsättning kring 8 milj. kr.

Jönköpings Mekaniska Werkstad (JMW)[14]

JMW gav sig in i marknaden för dränkbara pumpar i ett sent stadium av marknadens utveckling. Länspumpar för byggarbetsplatser och gruvor passade inte in i JMW's försäljningsorganisation, däremot hade man via ägaren Zander & Ingeström (Z&I) en anknytning till den kommunala vatten- och avloppssektorn. Z&I's avdelning för VA-anläggningar hade en stark ställning på den svenska marknaden. De dränkbara avloppspumpar man behövde köptes under 1960- och 70-talet från Flygt. Z&I betraktade dock Flygt som en konkurrent, och började bearbeta dotterbolaget JMW's ledning om att utveckla en egen serie dränkbara avloppspumpar. Z&I var samtidigt svensk agent för det franska pumpföretaget Pompes Guinard, och man föreslog att utvecklingsarbetet skulle bedrivas i samarbete mellan de båda företagen. Konstruktions-

[14] Avsnittet om JMW bygger på intervjuer med Kjell Alfredson 30/8 1993 och Ivan Eriksson 4/5 1993.

arbetet inleddes 1977/78. Pompes Guinard fick ansvaret för de mindre storlekarna, medan JMW utvecklade de större varianterna. Z&I kunde garantera JMW's pumpar en god avsättning på den svenska marknaden, men de största volymerna kom att säljas av JMW's amerikanska agent Comline Sanderson.

När JMW köptes av Scanpump 1982 bröts samarbetet mellan JMW och Pompes Guinard, eftersom Scanpumps pumpprogram konkurrerade med Pompes Guinards. Efter Scanpumps köp av Pumpex 1986 kom JMW's program av dränkbara avloppspumpar att integreras inom Pumpex.

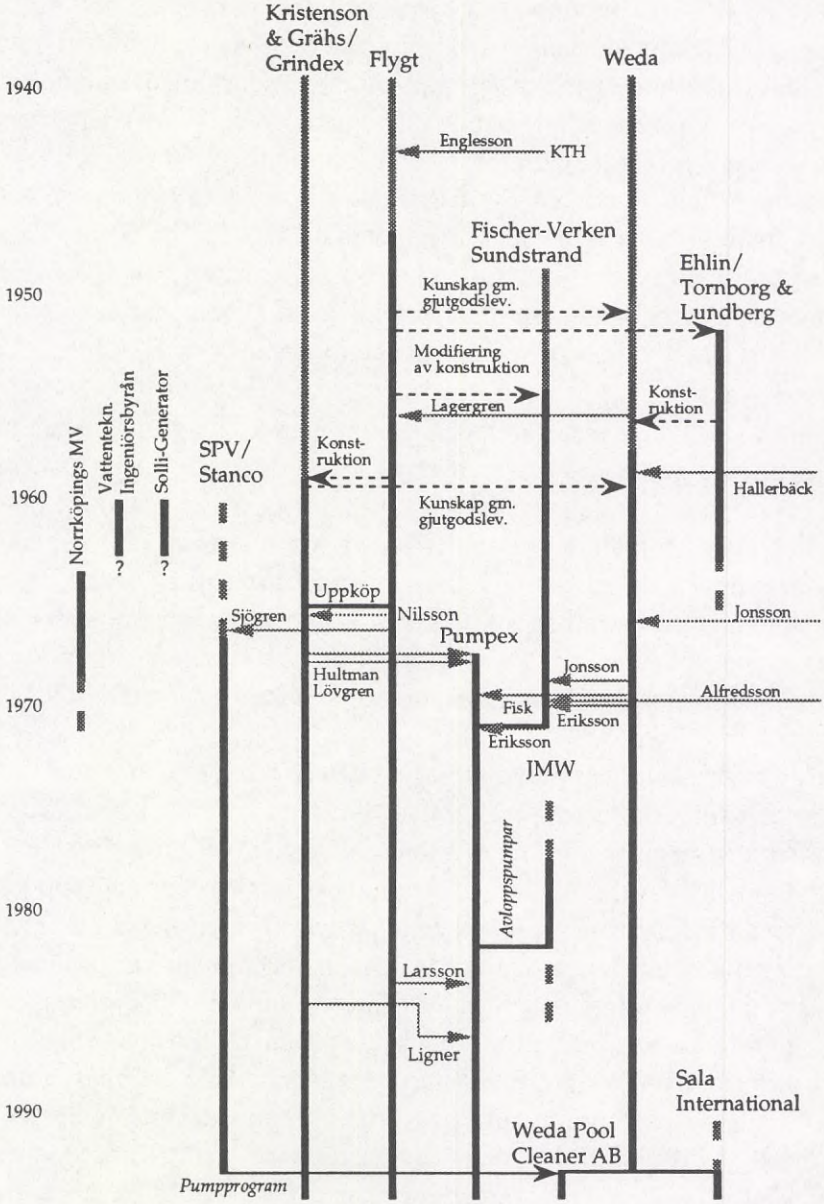
Diskussion

De dränkbara pumparnas branschhistoria skulle kunna vara ett läroboksexempel på hur en innovation ger upphov till en grupp av konkurrerande företag, genom att kunskaper, erfarenheter och teknologi sprids från ursprungsföretaget via imitation och via personer som byter företag. I figur 2 sammanfattas när olika tillverkare av dränkbara pumpar i Sverige uppträdde i branschen, och vilka nyckelpersoner som rört sig mellan företagen.

Det företag som gjorde innovationen, Flygt, utvecklades mycket snabbt till ett även i internationellt perspektiv stort företag. En viktig orsak till framgångarna under ett tidigt skede var det omfattande kontaktnät som Sixten Englesson hade bland strategiskt viktiga kunder. Genom dessa kontakter kunde produkten tidigt provas ut av kompetenta och respekterade användare, t.ex. Gatukontoret i Stockholm och Vattenfall. Härigenom kunde Flygt snabbt bygga upp en marknadsposition både i Sverige och internationellt som var mycket svår för konkurrenterna att på allvar hota. En annan viktig orsak till Flygts mycket starka position är sannolikt den grundidentitet som ett starkt marknadsorienterat företag som fanns som ett arv från grundaren, Hilding Flygt. Genom sammanslagningen av Flygts Pumpar och Lindås Gjuteri- och Formfabrik 1947 fusionerades även två skilda grundidentiteter på ett mycket fruktbart sätt. Det förra företaget var ett försäljnings- och installationsföretag med en utpräglad serviceinriktning, medan det senare var ett gammalt verkstadsföretag som genomsyrades av ägarfamiljens stabilitet och småländska tillverkningsfilosofi med betoning på långsiktig och gedigen företagsbyggnad.

I flera fall har motiven för efterföljarna till pionjärföretaget varit sökandet

Figur 2 *Länkar mellan svenska tillverkare av dränkbara pumpar*



Anm.: Feta svarta linjer visar när resp. företag uppträdde som tillverkare av dränkbara pumpar.

efter nya produkter som kan ersätta vikande marknader för traditionella produkter (Grindex, Weda, SPV/Stanco). I några fall stötte man i sin normala verksamhet på den nya produkten, i synnerhet dess avigsidor, och såg en marknadspotential om man skulle kunna tillverka en liknande och helst bättre produkt (Ehlin, Fischer). I andra fall har affärsrelationer med en etablerad tillverkare skapat ett medvetande om den nya marknaden (Weda). Ytterligare en möjlighet är att personer som arbetat inom etablerade företag av olika skäl lämnar företaget och startar en ny, fristående tillverkning (Pumpex). Som framgår av figuren är det få personer som lämnat Flygt för att ta anställning hos konkurrentföretag. I de flesta fallen har nyetableringarna av tillverkning skett genom att Flygts och andra tillverkares konstruktioner har analyserats, varefter erfarna konstruktörer utvecklat en egen variant.

De flesta av de tillkommande företagen i branschen höll sig uteslutande till länspumpar, och tog inte upp tillverkning av avloppspumpar. Detta är naturligt med tanke på att marknaden för avloppspumpar ställer betydligt högre krav på företagens försäljningsorganisation. Länspumparna säljs separat i standardiserat utförande, medan avloppspumparna ofta ingår i försäljningen av hela anläggningar. En annan viktig orsak till att färre företag utvecklade dränkbara avloppspumpar var att Flygt hade ett starkt patent på en kopplingsfot som möjliggjorde enkel installation och service av pumparna.

Endast ett av de etablerade pumpföretagen i Sverige, JMW, började självt konstruera och tillverka dränkbara pumpar.[15] Detta kom dock sent, tre decennier efter den ursprungliga innovationen. Orsaken till att de etablerade företagen, t.ex. JMW, API, Vadstena, Arving, Foke, m.fl. inte tog upp konkurrensen med de dränkbara länspumparna var möjligen att dessa inte kunde avsättas genom den etablerade marknadsorganisationen, som var inriktad på andra typer av kunder (kommuner, industriföretag, hushåll, VVS-entreprenörer). Det är svårare att förklara varför företag som De Lavals Ångturbin, Elektroskandia och JMW inte utvecklade egna dränkbara avloppspumpar, eftersom Flygts nya avloppspumpar i rask takt slog ut dessa företags egna konstruktioner. I JMW's fall kan detta kanske förklaras med att man var fullt upptagen med utvecklingen av lastoljepumpar till de snabbt expanderande varven. Elektroskandia var under denna tid (1950-talets andra hälft) fullt

[15] Till de etablerade pumpföretagen under 1950-talet räknar jag bl.a. De Lavals Ångturbin, JMW, AB Pumpindustri (nuvarande ABS), Elektroskandia, Vadstena Pumpar, Skoglund & Olson, Arving och Landsverk.

upptagen med att rationalisera ett föråldrat och vildvuxet pump-program, och hade inte den utvecklingskapacitet som hade krävts. De Lavals Ångturbin lanserade ett eget system för avloppsstationer, "Lavasil", samma år som Flygt introducerade sina dränkbara avloppspumpar. Detta innebar att man hade ogynnsamma förutsättningar att byta till den dränkbara teknologin.

Ingen av Flygts efterföljare lyckades bygga upp en marknadsställning som tillnärmelsevis liknade Flygts. Till en del kan detta förklaras med Flygts försprång i uppbyggnaden av distributions- och servicenät samt kundacceptans, och en generellt sett skicklig strategisk ledning. En annan del av förklaringen finns i konkurrentföretagens inre egenskaper. I Ehlins fall marknadsfördes en tekniskt god produkt av ett företag som var starkt hemmamarknadsorienterat, inte hade en lämplig försäljningsorganisation för denna produkt, samt såg sig själv som i första hand leverantör av entreprenadmaskiner. Fischer saknade resurser att expandera, både vad gäller finansiering, utvecklingskapacitet och erfarenhet av försäljningsorganisation. Dessa resurser kunde ha tillförts genom Sundstrands övertag, men en utveckling av denna produktmarknad låg uppenbarligen inte i linje med moderkoncernens övergripande strategi. I Wedas fall fördröjdes sannolikt tillväxten betydligt dels av en grundläggande identitet som gjuteri, som fokuserade på tillverkning av insatsvaror, dels av interna konflikter. Grindex hade skickliga konstruktörer och försäljningsansvariga, men låg ca tio år efter Flygt, och var ett litet företag med begränsade finansiella och organisatoriska resurser. I Stancos fall (det minsta av företagen) tillverkades också erkänt bra produkter, men den alltför ensidiga marknadsstrukturen, samt "otur" med ägarna/agenten i USA gjorde företaget alltför sårbart för en långsiktig expansion.

Fallet dränkbara pumpar passar, åtminstone vid en ytlig betraktelse, mycket väl in i den modell för uthållig konkurrenskraft som skisserats av Michael Porter (1990), d.v.s. en regionalt koncentrerad grupp av rivaliserande företag som via en pool av kunskap, teknologi och kompetent arbetskraft samt ömsesidig stimulans utvecklar en stark internationell position. Det kan dock ifrågasättas om inte Flygt skulle ha utvecklats ungefär på samma sätt även utan den inhemska rivaliteten, då innovationen var radikal och hade en mycket stor global marknadspotential. I dagsläget utgör de svenska konkurrenterna en tämligen marginell företeelse för Flygt, i jämförelse med de stora tyska och japanska konkurrentföretagen.

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Jonas Norrby - Vattenfallschef under en tid dominerad av konflikter

"PÅ NORRBYS TID. Vattenfallshistoria med kraft, spänning och motstånd", är titeln på en nyligen utkommen bok med Nils Forsgren som författare. Boken är utgiven av Vattenfall, och är en följd av ett uppdrag där Forsgren fått fria händer att skriva om Vattenfall under Norrbys tid. Resultatet har blivit en välskriven, rikt illustrerad och intresseväckande bok på något mer än 200 sidor.

Även om bokens titel enbart refererar till Norrbys tid så är detta inte bara en bok om Vattenfall under dessa år. För att kunna sätta in sin skildring i ett större sammanhang ägnar nämligen Forsgren de första femtio sidorna åt att teckna huvuddragen i utvecklingen under de år Norrbys föregångare - Vilhelm Hansen, Gösta Malm, Waldemar Borgquist, Åke Rusck och Erik Grafström - var Vattenfalls chefer. När sedan Norrby efterträder Grafström 1970 så tar också huvuddelen av skildringen vid. Den disposition som Forsgren valt är tematisk. Ett val som i detta fall avgjort är att föredra framför en kronologisk uppläggning då det därigenom blir möjligt att sammanhängande följa viktiga frågor och samtidigt tydligt framhäva centrala brytpunkter i utvecklingen.

Norrbys tid, d v s åren 1970–1985, var tveklöst år som erbjöd stora svårigheter för personer med ansvar för Sveriges energiförsörjning. När Jonas Norrby för någon tid sedan blickade tillbaka på sina år som Vattenfalls generaldirektör minns han också tiden som en besvärlig tid dominerad av konflikter av olika slag, eller som han uttrycker det: "Framförallt synes mig tiden fylld av tumult, stundtals kaos av energipolitiska styrsignaler. Det som frapperar när man ser tillbaka är att vi trots allt lyckades uträtta en hel del."

Bakom Norrbys ord döljer sig i första hand minnen av den uppslitande kärnkraftsdebatten, men också av de händelser som tvingade fram en omprövning av oljans roll i svensk energihantering och av stridigheter om planerade vattenkraftsutbyggnader.

De teman som behandlas i Forsgrens bok rör bl a de antydda problemområdena, d v s oljans, kärnkraftens och vattenkraftsutbyggnadens. Andra teman behandlar satsningen på alternativa energikällor och de förändringar inom organisationen som sådan som krävdes av den nya tidsanda som kom till uttryck i förkortningar som MBL och ADB, i krav på ökad jämställdhet och i en förändrad organisation.

Även om mycket av det som behandlas är känt sedan tidigare är Forsgrens arbete värdefullt då det ger en samlad bild av frågor där minnesbilden i dag i vissa avseenden hunnit förlora en del av sin skärpa. Förutom att Forsgren på ett kunnigt sätt summerar ett antal viktiga energiteman, pekar han också på hur man från Vattenfalls sida klarade de kursändringar som krävdes i olika sammanhang. Att Jonas Norrby under dessa besvärliga brytningsår gav prov på mycket goda ledaregenskaper och därigenom starkt bidrog till att uppståndna svårigheter kunde klaras på ett smidigt och verkningsfullt sätt är tveklöst ett av de budskap som Forsgren för fram.

Norrbys och Vattenfalls agerande får gestalt bl a med hjälp av Norrbys dagboksanteckningar, en alltid lika vansklig källa som dock rätt utnyttjad kan ge extra färg åt en framställning men också bidra till att kasta nytt ljus över tidigare behandlade problemområden. I Forsgrens bok hör dagboksanteckningarna till det som tillför nya intryck, och det är särskilt i ett avsnitt som de givits en framträdande roll - den fråga som avses är det s k Kaitumprojektet. Det innebar att Kaitumsjöarna, som avvattnas österut genom Kaitum–älven-Kalixälven, skulle dämmas upp och att vattnet i stället skulle ledas genom en tunnel över till Kaitums kraftverk sydväst om sjöarna. Vattnet skulle sedan ledas vidare för att via den reglerade sjön Satisjaure först utnyttjas vid Vietas kraftstation och därefter komma Luleälvens kraftverk till godo. Kaitum kom att kopplas samman med ett av Vattenfall tidigare framfört förslag, Ritsem–projektet. Förslagen kom att bli livligt debatterade och även starkt kritiserade. I debatten kom elförsörjnings- och sysselsättnings–frågor att ställas mot frågor som rörde naturskydd och rennäring. Forsgrens flitiga utnyttjande av dagboksanteckningarna gör att vi här på nära håll får följa ett spännande politiskt spel, men också Norrbys och Vattenfalls agerande och våndor i en för dem angelägen fråga under tiden den 1 april 1970 och fram till det att riksdagen tog sitt beslut den 2 juni 1972. Det är ett avsnitt som, i likhet med flera andra teman som Forsgren behandlar, reser frågeställningar som borde verka utmanande för forskare också från andra fält än det teknikhistoriska. En from förhoppning är således att boken inte bara skall upplevas som läsvärd utan att den också skall komma att fungera som en inspirationskälla till fortsatt forskning på energiområdet.

Staffan Hansson

Nyttig läsning för systembyggare

Arne Kaijser, **I fädrens spår...: Den svenska infrastrukturens historiska utveckling och framtida utmaningar.** Carlsson Bokförlag, Stockholm 1994. 292 sidor.

Ovanför dörren till mitt arbetsrum hänger en skylt:

Varför teknikhistoria?
Jo, den som inte också ser bakåt när hon ska se framåt,
hon måste en dag se upp...

Detta motto, att utifrån historien diskutera samtidens frågor, fungerar som en grundsten i mitt arbete, och jag har personligen hjälpt till att bokstavligen upprätthålla detta, eftersom det var jag som fick spika upp skylten förra gången den trillade ner.

Detta motto förefaller även ha väglett Arne Kaijser i hans senaste projekt *I fädrens spår...* Författaren, som är verksam som docent vid Avdelningen för teknik- och vetenskapshistoria vid KTH, beskriver och diskuterar det historiska arv som finns inbyggt i den svenska infrastrukturen. Bokens titel syftar på den devis som möter vasaloppsåkaren vid målgången i Mora; "I fädrens spår, mot framtids segrar", vilket ska visa på just detta tunga historiska arv. Särskild tyngd läggs vid tele- och elsystemen samt järnvägarna, då dessa av tradition i Sverige byggts upp i statlig regi och dessutom är det inom dessa områden som de för närvarande största förändringarna pågår. Omvandlingen går snabbt, och under en hittills förvånansvärt stor politisk enighet. Denna process betydelse för landets framtida ekonomi kan knappast underskattas. Därför är det viktigt, för att återknyta till inledningen, att veta vilka motiv som legat bakom utformningen av infrasystemen så att man som författaren säger "vet vad man överger - och varför".

Infrasystem och infrastruktur är återkommande och centrala begrepp i boken. Med infrasystem menas ett visst system, exempelvis elsystemet, medan infrastruktur syftar på summan av infrasystemen i samhället. Infrasystemen utgör samhällets fysiska underbyggnad, och betraktas ofta som rent tekniska system bestående av en mängd komponenter. Men det krävs även människor, organisationer och rättsliga och ekonomiska regler för att upprätthålla systemen. Därmed får infrasystemen en djupare samhällelig betydelse och kan därför kallas för sociotekniska system. Detta är ett grundläggande tema i boken.

Det teoretiska avstampet tar Kaijser från den amerikanske teknikhistorikern Thomas P Hughes som blivit en förgrundsgestalt vad gäller analyser av utvecklingen av stora tekniska system. Ämnet torde vara bland de mest forskningsintensiva inom teknikhistoria.

Boken består av tre delar. Dessa kan ses som ett försök att ur skilda perspektiv beskriva infrastrukturens omvandling. Den första delen omfattar tre kapitel och har ett analytiskt perspektiv. För att ingen ska behöva tvivla på infrasystemens betydelse inleds första kapitlet med en god genomgång av dess värde för olika kulturer. Man får lära sig att det inte är en tillfällighet att Europas första högkultur uppstod vid östra Medelhavet. Transporter gick vid den tiden smidigare på vatten än på land. Detta underlättade handeln mellan de grekiska öarna, vilket stimulerade ekonomin och skapade förutsättningar för tillväxt. Romarriket hade inte kunnat dominera så starkt militärt och politiskt utan sina vägar, vilka gav den romerska hären möjlighet till snabba truppförflyttningar för att slå ner provinsiella uppror. Vidare får man lära sig att även den stora omvandlingsprocess som vi brukar benämna industrialismen förutsatte förbättrade transportsystem på land. Den svenska utvecklingen präglas på det nationella planet utöver den påfallande statliga närvaron även av militär påverkan; kanaler, järnvägar och telegraflinjer byggdes upp under militär planering och ledning.

Återstoden av första delen ägnas åt en genomgång av infrasystemens funktioner och egenskaper, samt deras dynamik. Detta är bokens mest svårlästa del, med en i mitt tycke överdriven djupdykning i en begreppsvärld som ändå känns onödig att lägga på minnet för den fortsatta framställningen. Tyvärr kan dessa kapitel avskräcka läsare utanför forskarvärlden från fortsatt läsning. Att nå ut till en bred målgrupp är en av målsättningarna med boken. Ordet departementspromemoria, vilket delar av boken ursprungligen var tänkt att publiceras som, tycks ha surrat i författarens bakhuvud under skrivandet av dessa kapitel.

Den andra delen av boken har ett kapitels omfång och går under namnet *Historia*. Här avhandlas framförallt den svenska statens roll i förhållande till hur de olika infrasystemen har byggts upp, etablerats och förändrats. Jämförelser görs med utvecklingen i andra länder, framförallt europeiska men även med USA. Detta är, enligt min mening, den intressantaste av bokens delar, belyst av givande diagram och en rik notapparat. Den omfattande begreppsvärld som tynger det föregående kapitlet är borta. Man behöver heller inte vara ingenjör för att tillägna sig kapitlets teknikavsnitt. Tyvärr försvinner texten till vissa av diagrammen och bilderna i bokryggens lim mellan sidorna på uppslaget - en miss som Carlsson Bokförlag får ta på sig. Kapitlet avslutas med en evaluering av "den svenska modellen" inom infrastrukturen, och fungerar som en övergång till bokens avslutande del.

Bokens tredje del har titeln *Framtid*. Denna omfattar fyra kapitel, och är liksom den föregående illustrerad av belysande diagram. Tyvärr saknas dock källanvisningar till dessa. Författaren diskuterar inledningsvis de yttre omständigheter som tillsammans med ett förändrat ideologiskt klimat medfört att "den svenska modellen" omprövats. Förutsättningarna idag skiljer sig radikalt från de som rådde under 1800-talet, då de flesta av systemen byggdes upp. Kraven som ställs nu är fundamentalt skilda från dåtidens. Miljön har de senaste årtiondena seglat upp som en stark pådrivare av förändringar. En ny konkurrenssituation har också uppstått. Förr rådde den i huvudsak mellan de olika systemen. Nu råder den största konkurrensen inom respektive infrasystem. Troligen uppfattar inte Posten och Telia varandra som tävlande om samma marknadssegment, vilket man bör ha gjort förr. Idag är de båda företagens konkurrenter istället de privatägda Citymail respektive Tele2. Bägge företagen inriktar sin verksamhet på de mest lönsamma områdena av marknaden, områden som tidigare subventionerat mindre lönsamma delar av verksamheten. Man kan alltså inte kopiera gårdagens lyckosamma lösningar.

Kaijser formulerar avslutningsvis långsiktiga mål för en ny "svensk modell" och en strategi för att nå dit. Hans lösningar förefaller trovärdiga och önskvärda. Detta framtidsperspektiv är intressant för att komma från en teknikhistoriker. Man lugnas dock av att veta att författaren har haft en tidigare verksamhet som framtidsforskare.

En av bokens största lärdomar är insikten om den vånda politiker i en parlamentarisk demokrati måste befinna sig i när de tvingas att välja mellan att fatta långsiktiga och mer bärkraftiga beslut i motsats till kortsiktiga och populistiska ställningstaganden. Påfallande är den brådska och brist på beslutsunderlag som omvandlingen av infrastrukturen hittills har haft. Att ändra riktning i så stora frågor kräver långsiktigt uppsatta mål och konsekvens i genomförandet. Framförallt kan man hoppas att boken ger beslutsfattare en fördjupad syn på teknisk utveckling, dess förutsättningar och konsekvenser.

Med den aktualitet ämnet har och den förståelse Arne Kaijser besitter förtjänar boken att läsas, trots vissa tunga kapitel, av människor utanför den närmsta kretsen av akademiskt rotade teknikhistoriker. Det är den väl värd.

Om än inte direkt underhållande så är i alla fall boken mycket lärorik. Historien har alltid något viktigt att lära oss.

Ulf Andréasson

Ny vital teknikhistoria från Danmark

Hans Buhl & Henry Nielsen (red), **Made in Denmark? - Nye studier i dansk teknologihistorie**. Forlaget KLIM, Århus 1994. 303 sidor.

Med början 1990 har en allt stridare ström av teknikhistoriska böcker nått oss från Danmark:

Keld Nielsen, Henry Nielsen & Hans Siggard Jensen, *Skruen uden ende* (rec. i *Polhem* 1991/1).
Helge Kragh, *I røg og damp: Dampmaskinens indførelse i Danmark* (rec. i *Polhem* 1993/4).
Arne Jakobsen & Jørgen Johansen, *Fremskridtets frontløber.*
Michael E, Wagner m.fl., *Den ny teknologihistorie.*
Henry Nielsen, Hans Buhl & Hans Siggard Jensen, *Sender og Modtager.*
Hans Buhl & Henry Nielsen (red), *Made in Denmark? - Nye studier i dansk teknologihistorie.*

Framgången med den första av dessa böcker har säkert varit en stor inspiration till de senare skrifterna. I motsats till *Skruen uden ende* behandlar dessa nästan uteslutande danska teman. Antologin *Made in Denmark?* kan ses som en engagerad programskrift för en modern 'kontextuel' teknikhistoriesyn.

Inledningskapitlet av Keld Nielsen, "Ned ad fremskridtets boulevard" är en historiografisk översikt av ämnesområdet så som det utvecklats sedan 1959, det år då *Technology and Culture* utkom med sitt första nummer. Begrepp som "technological paradigm", "technological system" enligt Thomas P. Hughes och "social construktion of technology" (SCOT) presenteras och diskuteras i enkla, klargörande termer. Henry Nielsen och Michael Wagner ger sedan en översiktlig snabbkurs i dansk teknikhistoria från 1660 till 1990.

Huvuddelen av boken utgörs av åtta specialstudier inom dansk teknik- och industrihistoria. Nio författare skriver om smörproduktion, den misslyckade uppfinningen 'telegrafonen', Valdemar Poulsens radiosändare, vindkrafts-uppfinnaren Poul la Cour, Danmarks elektrifiering, kärnkraftsfrågan, genus-arbetsdelning i industrin och de danska ingenjörernas professionalisering.

Till sist följer ett för danska forskare mycket nyttigt kapitel om teknik-historisk källforskning med konkreta uppgifter om olika danska arkiv, samt ett kapitel om industriminnen och industriminnesvård i Danmark.

Trots de delvis disparata bidragen till boken ger den i sin helhet en god översikt av dansk teknikhistoria. Men framför allt ger den många exempel på modern 'kontextuel teknologihistorie', så olik gamla tiders.

Jan Hult

Notiser

Nyutkommen litteratur

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Jørgen Johansen & Arne Jakobsen, **Fremskridets frontløber. Ingeniøren i dansk litteratur**. Teknisk Forlag, København 1992. 96 sidor.

Jan Erik Nilsson, Göte Nilsson-Schönborg, Anders Wästfelt & Berit Wästfelt, **Ostindiefararen Götheborg. Berättelsen om den sista resan, silvret, porslinslasten och utgrävningen**. Stiftelsen Ostindiefararen Götheborg 1994. 59 sidor.

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R.A. Church & E.A. Wrigley, General Editors, **The Industrial Revolutions**. Blackwell Publishers, Oxford 1994.

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Vol. 6: P. Temin (Ed.), **Industrialization in North America**. 741 pages.
Vol. 7: W.J. Macpherson (Ed.), **The Industrialization of Japan**. 506 pages.
Vol. 8: D.T. Jenkins (Ed.), **The Textile Industries**. 438 pages.
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Andrew Mathewson & Derek Laval, **Brunel's tunnel ... and where it led**. Brunel Exhibition, Rotherhite 1992. 77 pages.

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Henry Petroski, **Design Paradigms. Case Histories of Error and Judgment in Engineering**. Cambridge University Press 1994. 209 pages.

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Nicholas J. Schnitter, **A History of Dams - The Useful Pyramids**. A.A. Balkema, Rotterdam 1994. 266 pages.

M.R. Smith & L. Marx (Eds.), **Does Technology Drive History? The Dilemma of Technological Determinism**. MIT Press, Cambridge, MA 1994. 280 pages.

John H. White Jr., **The American Freight Railroad Car, From the Wood-Car Era to the Coming of Steel**. The Johns Hopkins University Press 1993. 665 pages.

Julie Wosk, **Breaking Frame: Technology and the Visual Arts in the Nineteenth Century**. Rutgers University Press 1994. 275 pages.

Informationstekniken nu, då, sedan

I år firar världens äldsta ingenjörsvetenskapsakademi, IVA, 75 år. Tekniska Museet fyller 70. IVAs jubileum firas med en rad aktiviteter, bland annat en IT-festival i oktober. Det jubilerande och ombyggda Tekniska Museet arrangerar tillsammans med IVA den 25 oktober ett teknikhistoriskt seminarium kring IT, kring informationsteknikens historia, nutid och framtid.

Eftersom IT rör sig fortare än annan teknik — tjugo gånger snabbare, om vi får tro amerikanska forskare — så ställs det annorlunda krav på historikern. Historia, nutid och framtid tenderar att flyta samman, något som seminariet speglar.

Det riktigt långa perspektivet tar sålunda docent Eric Dyring, tidigare bland annat chef för Tekniska Museet, upp när han reflekterar över betydelsen av uppfinningen av nollan, som kom in i talsystemet senare än ettan. Och fil dr Michael Lindgren beskriver inte bara ett pionjärverk, far och son Scheutz´ unika mekaniska dator, utan också hur det är att skriva denna tidiga IT-historia, vilket han gjort i sin avhandling.

Stig Hagström, universitetskanslern, har varit med om att skapa den framtid som nu är historia, hos Xerox´ berömda Palo Alto Research Center. Professor Bo Göranzon, KTH, har genom sitt intresse för yrkeskunskap — kan den datoriseras? — blivit en kritiker av de mer "framtidsimperialistiska" löftena om vad allt IT kan ta över av mänskliga funktioner och mänskligt tänkande. Fil lic Rune Petersson, Ellemtel, har i ett kvarts sekel intresserat sig för bilder i kommunikation och skapat ett antal kartor för vår orientering i medie- och IT-utveckling.

Dagens IT-historia har skapats och skapas ofta av unga människor, ibland tonåringar. Det berättar Mattias Söderhielm om, 23-årig nybliven civlingenjör som sysslat med datorer nästan halva livet och som just återkommit från Silicon Valley.

Därifrån kommer också en av USAs mest etablerade analytiker av framtidens IT och dess mänskliga och sociala konsekvenser, Paul Saffo, Director, Institute for the Future. Docent Madeleine von Heland, Konstvetenskap, Stockholms Universitet, slutligen, har i "Från Aquilonia" sökt beskriva inte tekniken utan gestalta det nya samhälle den kommer att möjliggöra, kunskapssamhället eller immaterialismens samhälle. Hon reflekterar över uppgiften att skriva framtidshistoria.

För mer information: Tekniska Museet, Box 27 842, 115 93 Stockholm eller IVA, Box 5073, 102 42 Stockholm, tel 08-791 29 00

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