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100 years of progress with Lonza

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100 Years of Progress with *LONZA*

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Abstract. In the past century, *Lonza* has developed from an hydroelectric plant into a specialized, globally operating chemical company. This growth was not a foregone conclusion but the fruit of innovative drive, market orientation, and bold decisions in difficult times. These attitudes are described in the following article that outlines the development of the product range from calcium carbide to organic intermediates and to highly sophisticated chemical and biotechnology-based exclusive manufacturing for leading life science companies.

1. Early Days, First Crisis: *Lonza* Pioneers and Their Achievements

1.1. *The Path to Electrochemistry*

Since prehistoric times, man has used fire to change materials. First wood and charcoal, then later coal and gas were the main fuels, producing temperatures up to 1300°. In 1800, *Volta*, a physicist from Como in Italy, invented the electric cell which supplied a constant electric current for the first time. Decades later, *Berzelius* in Sweden and the English chemist *Humphry Davy* succeeded in separating

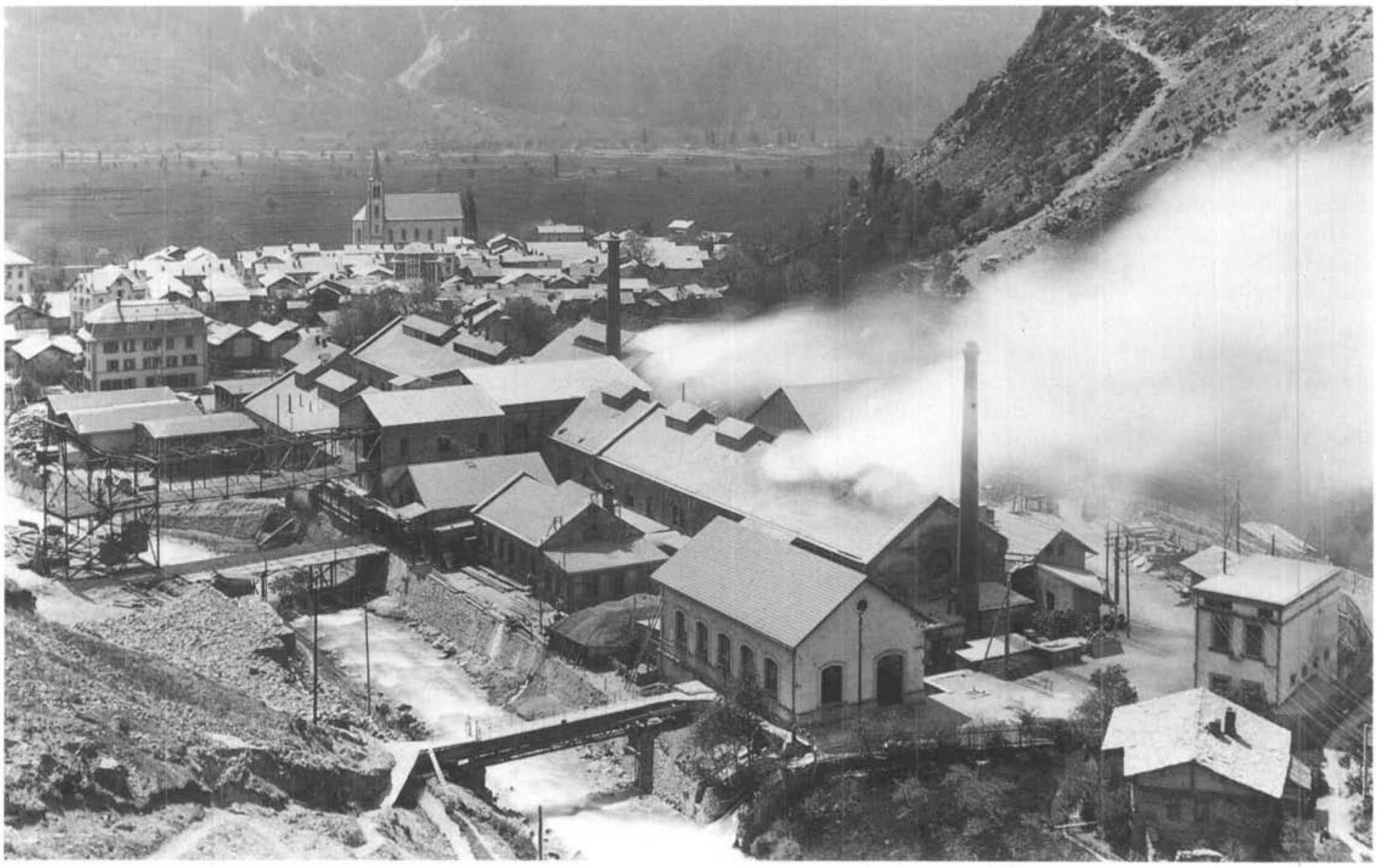

Fig. 1. *View from Lötschental of* Lonza*'s first production plant in Gampel, where calcium carbide was manufactured from 1898 to 1964 and calcium cyanamide from 1915 to 1970.* Photographed around 1915.

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chemical compounds using an electric current. But it was not, until the arrival of the dynamo and affordable electricity that the way was opened to electrochemistry. From around 1880 onwards, plants were built for separating a salt solution into chlorine and caustic soda. About the same time, electrolysis was used successfully to extract aluminum from anhydrous molten ore at *ca.* 1000°. This 'silver from alumina' was one of the sensations of the Paris Exhibition in 1889.

1.2. Lonza *Pioneers and the First Swiss Carbide Factory*

At the turn of the century, the application of such scientific discoveries in economically useful ways required great boldness and not a little patience. The original investors who put up the capital for the '*Lonza* Electricity Plant', founded on 29 October 1897 in St. Maurice, were full-blooded entrepreneurs, pioneers in the truest sense of the word. Their aim was to generate hydroelectric power and use it to manufacture electrochemical products. In 1897–98, the first big generating plant was constructed in Gampel, and – because it was still not viable to transmit electrical power over any great distance – a carbide factory was built next door.

The science of calcium carbide as it then stood consisted entirely of the research done by the French chemist *Henri Moissan* in 1892. The work of *Moissan* and his assistant *Bullier* marked the birth of the electrochemical industry in Europe. It did more to foster the growth of electrical engineering and hydroelectric power than the invention of the electric light.

In those days, it was enormously difficult to put scientific know-how into practice. With the tenacity that was already a typical *Lonza* characteristic, the nascent technology was further refined until, on 27 August 1898, the furnaces were able to start operations: at *ca.* 2000°, coal and lime were 'united' to form calcium carbide (**1**), a grey-black 'stone' which, when brought into contact with water, generated an inflammable gas: acetylene (**2**). Originally, calcium carbide (**1**) was used exclusively for the purpose of lighting. Acetylene (**2**) produced by mixing calcium carbide (**1**) and water burns with a bright white flame. The bright light of carbide lamps shone in every corner; they were even widely used as safety lamps on bicycles. The block method then employed to produce calcium carbide (**1**) entailed considerable wastage of raw materials and uneconomic utilization of electricity. Close contacts with carbide works abroad, such as *Elektro-Bosna* in Bosnia and *Hafslund* in Norway, produced significant advances in the development of furnace technology.

1.3. *The Lost Battle for Light*

Numerous carbide factories which sprang up before the turn of the century in a veritable speculative fever were without a sound technical or financial basis. Acetylene explosions in production plants and in lamps threw doubt on this method of illumination. At the same time, electrical engineering was booming thanks to the introduction of alternating current. Around 1905, the battle between carbide and electric light was decided. The carbide industry faced a new crisis and had to seek fresh areas of application. Mixed with oxygen, 'carbide gas' could be used for autogenous oxyacetylene welding; and combined with similarly reactive substances, it led to the development of many new chemical compounds.

Mastery of high temperatures, such as those necessary for the manufacture of carbide, gradually became a *Lonza* speciality. To the pioneering *Lonza* engineers of that time, the volatility of the carbide markets before, during, and after the First World War constituted a challenge in itself.

1.4. *Calcium Cyanamide to the Rescue*

The research of two German chemists, *Adolf Frank* (1834–1916) and *Heinrich Caro* (1834–1910), marked a turning point for the crisis-ridden carbide industry. *Frank*'s original experiment involved a stream of elementary atmospheric nitrogen directed over glowing calcium carbide (**1**). This was used as a basis for a process to manufacture calcium cyanamide (**3**) developed by *Frank* and *Caro* in 1899. It was not, until 1915 *Lonza* succeeded in developing industrial-scale production. This opened the way for processing of the company's own calcium carbide (**1**) to produce calcium cyanamide (**3**), the first synthetic fertilizer, which neutralizes acid soil and provides plants with a slow-release dosage of nitrogen.

$CaO + 3C$	→	$CaC_2 + CO$
Lime		**Calcium carbide**
		1
$CaC_2 + 2H_2O$	→	$C_2H_2 + Ca(OH)_2 + 34$ kcal/Mol
Calcium carbide		**Acetylene**
		2
$CaC_2 + N_2$	→	$CaCN_2 + C + 69$ kcal/Mol
Calcium carbide		**Calcium cyanamide**
		3

1.5. *The Carbide Boom and First Secondary Products*

The First World War prompted a boom in demand for calcium carbide (**1**) and its secondary products. International demand for carbide soared from 160000 metric tons in 1913 to 1300000 tons by the end of the war. In the warring countries, calcium cyanamide was in great demand as a basic substance for the manufacture of gunpowder and explosives. At the same time, industrial production of acetaldehyde (**4**) and acetic acid (**5**) opened up new possibilities for acetylene (**2**).

$C_2H_2 + H_2O$	→	C_2H_4O
Acetylene		**Acetaldehyde**
		4
$C_2H_4O + ½\,O_2$	→	$C_2H_4O_2$
Acetaldehyde		**Acetic acid**
		5

There was also a reduction process for turning acetaldehyde (**4**) into alcohol. The Swiss Federal Alcohol Authority approved the construction of a plant and signed a contract to buy, at a good price, a quantity corresponding to Switzerland's prewar requirements. Procuring the right equipment delayed the start-up of operations until the end of 1918. Altogether, only 100 metric tons of alcohol were supplied; high coal prices prevented any further production. In 1920, catastrophic overproduction in the immediate postwar years forced *Lonza*, not only to halve carbide production in Gampel and at the Visp plant (which had been opened in 1909), but also to close the carbide factories acquired earlier in Thusis and Chèvres near Geneva.

1.6. *More Pioneering Feats in Valais*

In France in 1907, 'Société L'Air Liquide-Paris' developed a process for separating air which had been liquefied at low temperatures. Here again was a challenge to *Lonza*'s already proverbial pioneering spirit. On the slope west of Gampel, in the 'Claude' plant – named after an engineer from L'Air Liquide –, nitrogen and oxygen were produced industrially from air. Compressed air is cooled, by repeated pressure drops, until it attains a liquid state; through fractionated distillation, the more volatile nitrogen can be separated from heavier oxygen at nearly –200°. Thanks to such low-temperature distillations, as well as its mastery of high temperatures and pressures, and electrolytic techniques, *Lonza* was able to tackle practically all chemical processes.

In the twenties, there was still no viable electrolyzer outfit for industrial-scale production of hydrogen. It was only with the discovery and development of water electrolyzers by *Pechkranz*, an engineer at *Lonza*'s Valais works, that the way was opened. The electrolyzers at the Ackersand electrolysis plant were fed with direct current from appropriately equipped generators at the company's power station. Altogether, Visp and Ackersand produced 5800 m^3 hydrogen per hour.

1.7. *Entry into Nitrogen Chemistry*

In 1925, *Lonza* became involved in ammonia synthesis. The process chosen by *Lonza* – making it the first licensee for industrial-scale production – was developed by *Ammonia Casale* in Rome, which used a pressure of 700 bar. At a temperature of 450°, a gaseous mixture of 75% of hydrogen and 25% of nitrogen is partly converted to ammonia in the presence an iron catalyst in thick-walled pipes. This ammonia is liquefied by cooling and separated from the remaining gas. Using this method, it takes 2000 m^3 of hydrogen to manufacture one metric ton of ammonia.

However, apart from ammonia, highly concentrated nitric acid was also much prized at that time. The process for manufacturing nitric acid, introduced in 1927, involved mixing ammonia gas with air and combusting it at *ca.* 800° as it passed through a fine platinum mesh to produce nitrogen monoxide. In the subsequent absorption plant, the nitrogen monoxide is further oxidized to nitrogen dioxide and absorbed in water. This forms nitric acid at a concentration of 50–60%.

Fig. 2. *In the late 1950s,* Lonza *decided to use oil rather than calcium carbide as its raw material.* In the fall of 1964, *Lonza* brought on stream the world's smallest industrial naphtha cracker in Lalden.

2. Consolidation and the Switch to Oil

2.1. *Fertilizer Chemistry at* Lonza

With calcium cyanamide (**3**) from Gampel and calcium nitrate made from nitric acid – both of them nitrogenous fertilizers – *Lonza* succeeded in establishing a foothold in the fertilizer industry. Starting around 1930, further active ingredients were added to produce a range of multi-nutrient fertilizers, better adapted to the requirements of crop plants. Supported by the LONZADATA soil analysis system, fertilizer sales reached a peak in the eighties. In 1990, a compressed fertilizer plant came on stream. Subsequently, great competitive pressure and new methods of cultivation introduced to the farming industry led to a sharp decline in the significance of the fertilizer industry. Since 1993, the fertilizer pellet plant has fallen silent. Production has been pared down to ammonium nitrate and liquid fertilizers. *Lonza* has also pulled out of marketing these products, conferring the task on AGROline in Basel, a joint venture between *Lonza* and *CU Chemie Uetikon AG*.

2.2. *The Entry into Petrochemistry*

Towards the end of the fifties, the growing demand for organic products caused serious carbide shortages at *Lonza*. The furnaces worked at full blast. Although the smoke and dust plume rising above the carbide furnaces consisted mostly of relatively harmless magnesium oxide in aerosol form, as concern for the environment, the emissions came to be seen more and more as a nuisance. In major industrial centers abroad, the raw-material base was shifting from coal to oil and natural gas.

Unlike calcium carbide (**1**), petrochemical processing produces ethylene and acetylene (**2**) as well as hydrogen. This was posing a serious threat to *Lonza*'s international competitiveness. The company had no choice but to join the worldwide move to petrochemicals. The upshot was the construction of the naphtha-cracking plant at the Valais Works, for which *Lonza* chose the *Fauser* process offered by *Montecatini*. The decision to change the raw-material basis was announced at the Annual Shareholders' Meeting in 1959.

Construction of the naphtha cracker was completed – some way behind schedule – in the autumn of 1964; the cost reached CHF 130 Mio. The supplier was clearly overextended by the problems of getting an efficiently operating installation up and running. For example, during the test run it was overlooked that a combination of soot and tar quickly blocked the many pipes. In the end, *Montecatini* had to pay compensation of CHF 12 Mio. for failing to meet its contractual obligations. This sum was used to build a new research center. The apparently insurmountable problems with the installation galvanized *Lonza*'s own personnel into action. By dint of an exemplary effort and some 'homemade' improvements and additions, it took only six months to get the plant ready for production. This led to lines of organic starting substances and intermediates. The foundation stone for *Lonza*'s present structure was laid. Thanks to meticulous maintenance, the plant has been kept in almost continuous operation over the intervening decades.

2.3. *Basic Organic Chemicals*

Soon after the turn of the century, *Lonza* was among the founders of an 'International Consortium for the Electrochemical Industry', seeking possible applications in organic chemistry for acetylene made from carbide. Attention focused on acetaldehyde (**4**) as an intermediate for acetic acid (**5**), itself a source of highly prized derivatives. Acetaldehyde (**4**) plays a key role in *Lonza*'s organic chemicals activities as the basis for various multistage processes. Given the right conditions, acetaldehyde (**4**) can be converted into a wide range of valuable derivatives. Metaldehyde (**7**) and other compounds such as paraldehyde (**6**), acetic acid (**5**), ethyl acetate were to become star products for *Lonza*.

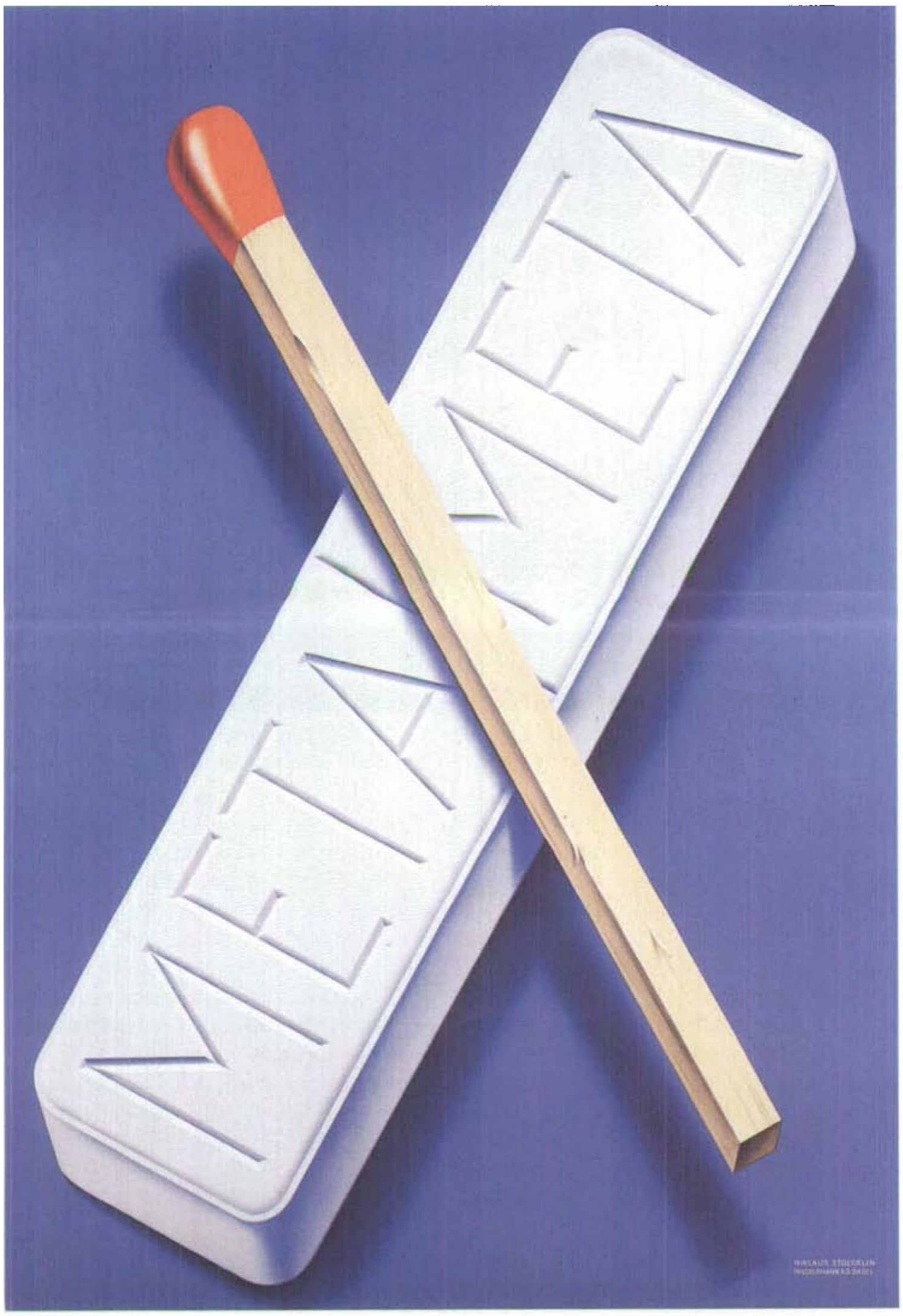
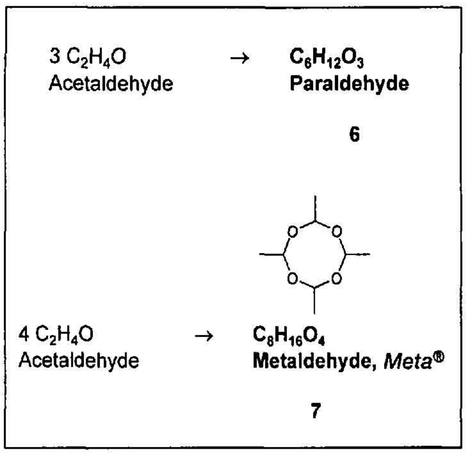


Fig. 3. *Starting in 1920,* Lonza *began the manufacture of metaldehyde, known by the trade name Meta*®. Production started in 1923. *Meta*® tablets were sold for decades as kindling and fuel. Today, the product is used almost exclusive to combat slugs.

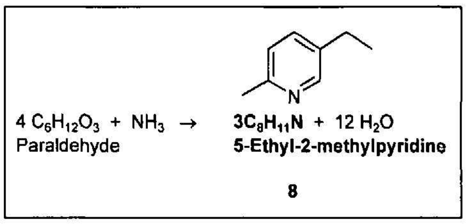


$3\ C_2H_4O$ Acetaldehyde $\rightarrow$ $C_6H_{12}O_3$ **Paraldehyde**

6

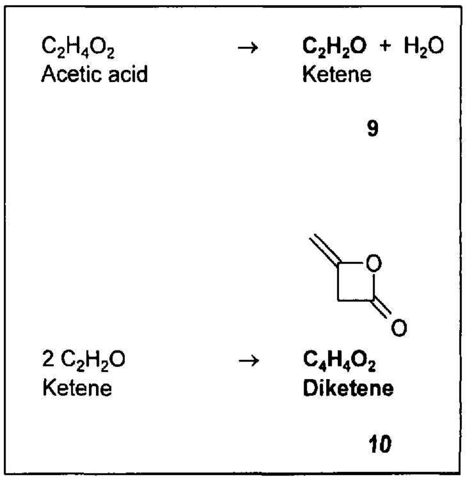
$4\ C_2H_4O$ Acetaldehyde $\rightarrow$ $C_8H_{16}O_4$ **Metaldehyde, *Meta*®**

7



$4\ C_6H_{12}O_3 + NH_3$ Paraldehyde $\rightarrow$ $3C_8H_{11}N + 12\ H_2O$ **5-Ethyl-2-methylpyridine**

8



$C_2H_4O_2$ Acetic acid $\rightarrow$ $C_2H_2O + H_2O$ Ketene

9

$2\ C_2H_2O$ Ketene $\rightarrow$ $C_4H_4O_2$ **Diketene**

10

2.4. Lonza *at the Service of National Food Provisioning*

During the Second World War, *Lonza*'s research and development was placed at the disposal of national provisioning. Initially, the priority was fertilizer manufacture to boost food production. Later, the company became a supplier of solvents, substitute fuel components, ersatz rubber, alloy components, starting materials and intermediates for manufacture of varnishes and paints, dyestuffs, pesticides, textile processing products, and pharmaceuticals. During this period, the vinyl chloride business was built up, later to be

Fig. 4. *This outdoor ketene/diketene plant* (picture) *of the Valais Works came on stream in 1993. Lonza* has another diketene plant in Bayport, USA, and is the world's largest producer of diketene.

relocated to Sins (Canton of Aargau) and finally abandoned due to international competition.

2.5. Meta® – *One of* Lonza's *Star Products with Many Applications*

Metaldehyde (7) production resulted from the search for a solid 'alcohol' based on acetaldehyde (**4**). For decades, metaldehyde (**7**), sold as *Meta*®, was one of the world's leading brands of solid fuel. In the period after 1923, the manufacture of *Meta*® played a crucial role in *Lonza*'s economic recovery. Crystalline *Meta*® is formed under the influence of suitable catalysts at temperatures below 0° through the bonding of four acetaldehyde molecules. The crystalline *Meta*® is separated from the liquid by-product paraldehyde in centrifuges; a stream of inert gas dries the product, to which a stabilizer has been added. After drying, the metaldehyde is in the form of a voluminous powder, which is pressed into small elongated tablets for sale as a fuel. Unfortunately, *Meta*® is poisonous. To prevent accidental ingestion by children, the tablets were impregnated with a bitter substance and given a repellent mouse-grey colour. Despite these precautions, *Meta*® fell foul of the new law on poisons in the seventies; its sale in Switzerland was restricted to drugstores. This led to the abandonment of *Meta*® as a fuel in 1985; the tablet-pressing plant was closed down. Since that time, production has continued at a good level thanks to demand for metaldehyde as a slug repellent (a use discovered by accident in 1936).

2.6. *Paraldehyde as a Substitute Fuel*

Shortly after the start of the Second World War, the Confederation asked *Lonza* to produce substitute fuels for the army and farming industry. A process was rapidly developed to manufacture the paraldehyde fuel component for admixture with benzene. On 24 February 1941, the first liveried tanker was ready to deliver *Lonza* fuel. When those deliveries ceased, *Lonza* was able to put the paraldehyde (**6**) to good use. As the basic material for the synthesis of 5-ethyl-2-methylpyridine (**8**), paraldehyde (**6**) is the starting point for the important field of pyridine chemistry, about which more later.

3. Expansion and Development of Product Lines

3.1. *Diketene Chemistry: From Acetic Acid to Artificial Silk and Intermediates*

Ketene (**9**), a gas with a boiling point of –45°, is produced by cracking of acetic acid (**5**) at temperatures of 600–700° in the presence of an acidic catalyst. Shortly before the vaporous stream of acetic acid (**5**) enters the separating coil, the strongly acidic triethyl phosphate is added to catalyze the separation. Ketene manufacture, started by *Lonza* in 1928, eventually developed into the second most important family of products at the Valais Works. Gaseous ketene reacts rapidly and must be converted into a more stable secondary product. This is achieved using a continuous process.

When production started, the aim was to market ketene (**9**) as an intermediate for the manufacture of cellulose acetate, the raw material used to make artificial silk (rayon). Because sales failed to match expectations, *Lonza* set out to develop its own alternatives. In 1928, a silk-spinning mill was installed in Visp, which continued production until 1932. In the early thirties, this was followed by proprietary developments in the relatively young field of acetate silk. The German market soon offered the right economic conditions for large-scale industrial production. In 1935, '*Lonzona AG für Azetat-Produkte*' began making acetate silk at its plant in Säckingen (Baden), using its own proprietary process. This was later followed by the *Lonza Works* at Weil am Rhein, Germany.

For nearly 20 years up to 1947, ketene (**9**) was used exclusively for the production of acetic anhydride. Since 1947, *Lonza* has used ketene primarily for the manufacture of diketene (**10**), a colorless liquid, a highly reactive substance. Because of its low stability – keeping only a few days at room temperature –, diketene (**10**) cannot be transported in any great quantities over public roads or by rail. It is therefore converted into more stable derivatives directly at the Valais Works. Diketene's high reactivity makes it a rich source of secondary products, and over the decades, *Lonza* has developed a broad family of diketene derivatives (various acetoacetic esters and arylides, alkylamides and dehydroacetic acid). All of these products serve as intermediates: a few are processed directly by *Lonza*, but mostly they are used by chemical manufacturers in all corners of the world to make end products, often in multistage processes.

After modest beginnings in 1928, *Lonza*'s ketene manufacture underwent major expansion in 1947 and 1991. Since 1993, a state-of-the-art ketene/diketene outdoor plant with a ketene capacity of 18 000 t per year has been in operation. Two furnaces burning natural gas are marked by tall slim chimneys almost 40 m high. Through the plants in Visp and Bayport, Texas, *Lonza* today supplies a quarter of the world's diketene needs.

3.2. *Pyridine Chemistry*

Pyridine chemistry is the strongest branch of the various families of products made by *Lonza* today. It originates from C_2 chemistry and forms the basis for production of high-value-added products. Originally, *Lonza* produced these C_2 building blocks from calcium carbide (**1**) in the form of acetylene (**2**), and since the sixties from the naphtha-cracking plant as acetylene and ethylene. The key product of pyridine chemistry is 5-ethyl-2-methylpyridine (**8**), which can be manufactured either directly from acetaldehyde (**4**) or *via* paraldehyde (**6**). In the original process, an aqueous solution of ammonia and acetic acid (**5**) is reacted with paraldehyde (**6**) at a temperature of *ca.* 20° and a pressure of 100 bar. The reaction takes place on a continuous basis in a two-inch pipe (2000 m in length), which passes through twelve oil-heated modules. The installation, which came on stream in 1956, was extended and improved in 1972 and 1993. Today, most of the 5-ethyl-2-methylpyridine (**8**) output is used by *Lonza* itself to manufacture nicotinic acid (= niacin, **11**).

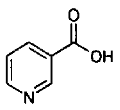
3.3. *Niacin, a Pyridine Derivative Essential to Life*

In the 18th and 19th centuries, the human and animal populations of various parts of Europe and North Africa were affected by epidemics, which manifested as skin inflammations and diarrhoea. Some people actually suffered mental illness as a consequence of the affliction. It was noticeable that the geographical distribution of the disease – which became known as pellagra (from the Italian for 'rough skin') – coincided with areas of maize cultivation. It was 1930, before the cause of pellagra was discovered: the deficiency of an essential vitamin based on nicotinic acid. Unlike other staple foodstuffs, maize (sweet corn) does not supply any nicotinic acid that can be absorbed by the body. Because of its vitamin effect, nicotinic acid – more widely known by its commercial name of niacin (**11**) – and its derivative niacinamide, were called vitamin PP (pellagra-preventing). The relationship between nicotinic acid and its amide is interesting. Only the latter can be regarded as a true component of the vitamin. Once the human or animal body is supplied with nicotinic acid, it is capable of synthesizing the amide which has the actual vitamin effect itself. Accordingly, both forms are equally effective.

3.4. *The Path to Synthetic Niacin*

Once the significance of niacin (**11**) as a vitamin source had been recognized in 1937, scientists started searching for a means of synthetic manufacture. In this field, *Lonza*'s great advantage was to have at its disposal ample quantities of all the key basic substances: paraldehyde (**6**), ammonia, and nitric acid. At the end of the forties, *Lonza* made a test run with an unpressurized catalytic process. Industrial production of niacin (**11**) began in 1956. The process was based on direct conversion of 5-ethyl-2-methylpyridine (**8**) into niacin (**11**) in autoclaves. Annual output was several hundreds of tons. In 1963, the first continuous process came on stream. Continuous improvements and refinements of the process and product quality have helped *Lonza* stay out in front as the world's market leader. Today, *Lonza* holds 60% of the world market for this important product. Around 10% of the niacin (**11**) produced is converted to niacinamide. Both forms are used as additives in food and beverages, in multivitamin preparations and in medicine.

The extent of *Lonza*'s global success in the field of niacin(amide) is demonstrated by the joint-venture construction of a niacinamide plant in Guangzhou, China, agreed on 20 November 1995.



$C_8H_{11}N + 6HNO_3 \rightarrow$ $C_6H_5NO_2 + 6NO + 6H_2O + 2CO_2$

5-Ethyl-2-methylpyridine **Niacin**

11

3.5. *Hydrocyanic-Acid Chemistry*

Besides the diketene and pyridine derivatives already mentioned, the third major family of products manufactured by *Lonza* is that based on hydrocyanic-acid (HCN) chemistry. Otherwise known as prussic acid or hydrogen cyanide, HCN is a colorless, extremely toxic liquid which smells of bitter almonds and boils at 26°. At the end of the fifties, a group of researchers was set the task of finding a way of producing hydrocyanic acid from simple hydrocarbons and ammonia. The first hydrocyanic-acid plant came on stream in 1963, with a capacity of 1.5 t per day. But in 1966, production was temporarily halted, because the market had become flooded by low-priced hydrocyanic acid which was a by-product of acrylonitrile synthesis. In 1976, improvements to the acrylonitrile process had substantially reduced the output of hydrocyanic acid – which was basically an unwanted by-product –, and *Lonza* decided to purchase a licence for the *Degussa* process and build a new hydrocyanic-acid plant at the Valais Works. A particular concern was the hygiene and safety problems connected with the production and handling of this highly

Fig. 5. *View of the niacin building completed in 1971. Lonza*, the world's biggest niacin manufacturer, has been producing this B-complex vitamin since 1956 and has a market share of *ca.* 60%.

poisonous substance. In the manufacturing process, methane gas and ammonia are converted into hydrocyanic acid in appropriate conditions. The two gases are reacted at 1350° in heat-resistant tubes, which are coated inside with a thin layer of catalyst with a precious-metal base. The reaction tubes are suspended in bundles in ceramic ovens heated by a natural gas/air flame. A multistage refining process gives an aqueous solution with a hydrocyanic-acid content of 25%, which can be stored and sold to customers.

For *Lonza*, hydrocyanic acid has become an important building block for chemical synthesis. The most important area of application is in chloride compounds of HCN. *Ca.* 80% of *Lonza*'s hydrocyanic-acid output is converted into cyanogen chloride. In the fifties, *Ciba* asked *Lonza* to supply cyanuric chloride for the manufacture of brightening agents, as detergent additives. This prompted *Lonza* to develop its own process, in which cyanogen chloride is converted into cyanuric chloride at temperatures of 420–450°. This gave *Lonza* another key substance which opened the door to a wide range of derivatives. Besides cyanuric chloride, these include malononitrile, sodium dicyanamide, and a broad range of cyanoacetic esters and malonic acid. Malononitrile is used above all for the manufacture of vitamin B_1 (thiamine) and in the dyes and agrochemicals industries. The various cyanate esters are used in pharmaceuticals, dyestuffs and photographic chemicals, in fragrances and special plastics. From one derivative of cyanoacetic ester a versatile adhesive is made. Used widely as a secondary adhesive, it can even seal wounds.

4. Custom Manufacture and Biotechnology

4.1. *Fine Chemicals and Exclusive Products*

Like other manufacturers of basic chemicals, *Lonza* faces increasingly tough international competition. In view of this situation, *Lonza* began early on to extend its range beyond the above-mentioned product families by processing its basic chemicals to make higher-added-value products. Progress on this front demanded great versatility, not only on the part of research and development, but also in the production sphere: working on tight schedules, plants of the right type and capacity had to be made ready for new products. More and more plants were configured with flexible elements, thus paving the way for fine chemicals manufacture.

Fine chemicals are compounds with high-added value, produced in relatively small quantities, often as exclusive products for a single customer. Most fine chemicals undergo several stages of downstream processing to emerge as high-grade end products in the pharmaceutical, crop-protecting, or plastics industries.

Their manufacture places high demands on technical know-how and process engineering. The level of sophistication is reflected in fine chemicals pricing, which is several times higher than that of normal intermediates. In many cases, the demand for a particular fine chemical dries up after only a few years. This limited production life rules out building a dedicated plant for every product. *Lonza* has squared up to this technological challenge by building batch-operation multipurpose plants with diverse operational modules which can be combined and interconnected as required.

One of the key success factors in the fine chemicals business is free capacity. Only if such capacity is held in reserve, can it be mobilized at short notice. With the 'Leave it to *Lonza*' philosophy built around this simple idea, *Lonza* has become world number one as the largest and most versatile manufacturer of exclusive, customized products. Many of the leading pharmaceutical companies concentrate their efforts on the research, development, and marketing of speciality products, leaving actual production to a capable and reliable partner such as *Lonza*.

The real boom in fine chemicals at the Visp works began in 1980 with the decision to build the Fine Chemicals Complex (FCC), initially with two multipurpose production units. By the time work is completed in 1998, the massive, five-storey building, which is divided into several fire-resistant lobbies, will house six multipurpose plants. Apart from the actual production building, fine chemicals production requires a broad infrastructure with a machine house for cold- and compressed air production, heating and cooling systems, measuring and control technology and above all state-of-the-art waste disposal (for chemical wastes).

The fine chemicals manufactured at the FCC are extremely diverse in character. Apart from complex intermediates and its own products such as biotin and pyrimidine derivatives, *Lonza* makes active substances for pharmaceuticals and agrochemicals manufactured by some of the world's leading companies. Such exclusive products are subject to secrecy agreements, and details are never published.

4.2. *The Development of Biotechnology at* Lonza

Spurred by the rapid growth of industrial biotechnology during the eighties, *Lonza* decided in 1982 to harness the synergies between chemistry and bioengineering. The Visp research center set up a working group for biotechnology, initially with eight members. Besides customer-oriented projects, the aim was to explore new areas of biotechnological research. The initiative soon bore fruit. Following the discovery by a chemist of hydroxynicotinic acid – a mother liquor for niacin production – in laboratory samples, the biotechnology team developed the first bacterial production strain. In 1989, after further research and development work, *Lonza* was able to start manufacturing its first biotechnology product, 6-hydroxynicotinic acid, an intermediate for pharmaceuticals and crop-protection agents, on a continuous basis.

To keep pace with a stream of promising findings from biotechnology research, *Lonza* had to build a corresponding production infrastructure. With fortunate timing, a fermentation plant was acquired in 1992 in Kourim, Czech Republic. In 1993 and 1996, five 15 000-liter, multiproduct

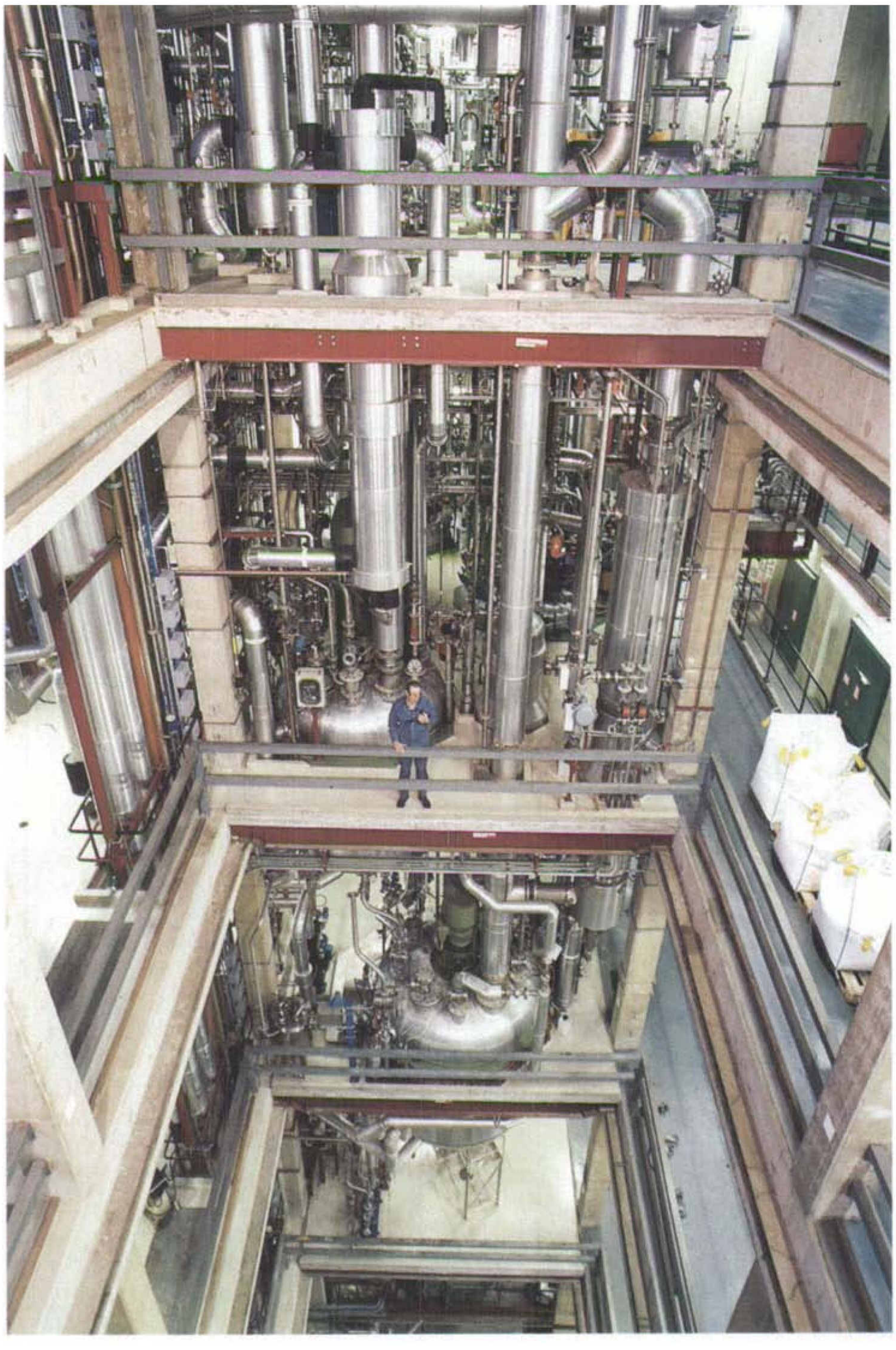


Fig. 6. *The Fine Chemicals Complex (FCC) has been continually expanded since 1984.* The picture shows the fifth multipurpose plant, which came on stream in 1995; the sixth is now being built.

Fig. 7. *View of the biotechnology pilot facility in Visp.* State-of-the-art pilot equipment includes 0.5-, 1.5-, and 15-m^3 fermenters as well as capabilities for product isolation and purification.

fermenters and a state-of-the-art 50 000-liter fermenter were added, as well as processing plants.

A further important step in extending *Lonza*'s technology offering came in 1996 with the acquisition of *Celltech Biologics*, a biotech company with a strong pharmaceutical focus. This company employs *ca.* 300 people at its centers in England and the USA. Through the combination of research and development at Visp, the fermentation plant in Kourim, and *Celltech Biologics* (which now trades as *Lonza Biologics*), *Lonza* has built a strong position in the biotechnology field. The range of technologies available for custom manufacturing reaches from organic syntheses, through biotransformation and fermentation, to the use of animal cell cultures.

Besides exclusive products for customers, *Lonza* researchers have developed a proprietary process for biotechnological synthesis of L-carnitine. Today, this nutrient additive, used *e.g.* in fitness drinks, has become one of the leading products of the Kourim fermentation plant.

Biotechnologically produced substances have become the third cornerstone of *Lonza*'s business, alongside organic intermediates and fine chemicals. This symbiosis between classic chemical synthesis and bioengineering techniques – particularly in custom manufacturing for leading companies – will play a vital part in securing the company's future.

5. Internationalization and diversification

In keeping with our centennial motto "100 years of progress with Lonza", we enter 1997 looking forward to the future. But we will not lose sight of the fact that today's achievements would have been unattainable without the visionary groundwork and pioneering spirit of previous Lonza generations. The farsightedness and commitment of our employees over the first hundred years are an enduring challenge to the present generation to keep its eyes set on new horizons and find innovative solutions to our customers' problems.

1897
In Gampel, Switzerland, on the banks of the Lonza river, work commences on a power plant and calcium carbide factory.

1919
Lonza moves its head office to Basel, Switzerland.

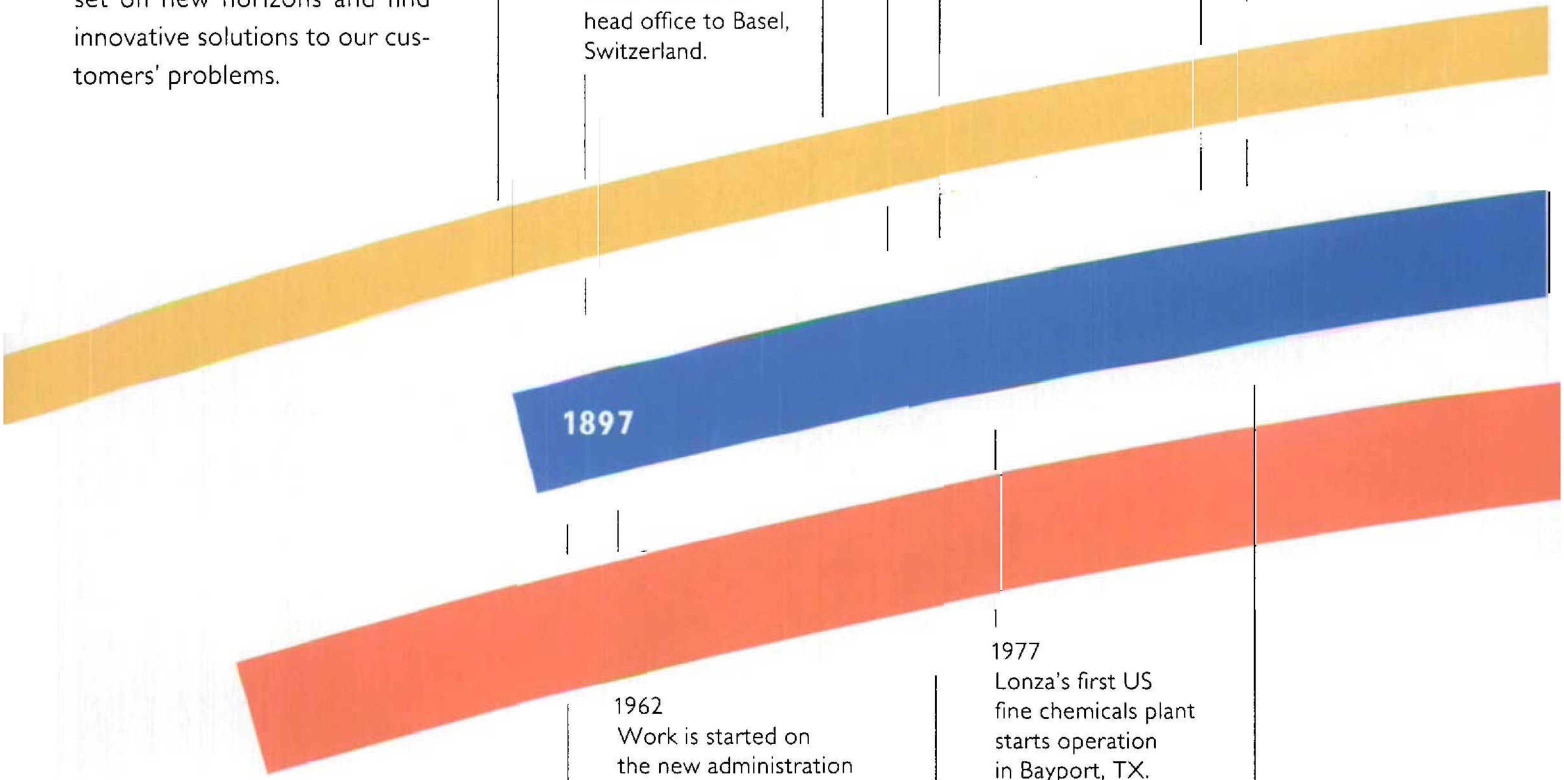
1962
In Scanzorosciate, Italy, Lonza acquires the Ftalital works which manufactures intermediates for polyester resins.

1965
The world's smallest industrial naphtha cracker comes on stream at the Valais Works.

1974
Alusuisse acquires Lonza Ltd.
The Alusuisse-Lonza Group is created.

1980
Acquisition of a plant producing special surfactants at Long Beach, CA.

1980
The San.Giovanni Valdarno site in Italy is acquired. The plant produces plasticizers and unsaturated polyester resins.



1909
Production of basic fine chemicals starts up at the Valais Works in Visp, Switzerland.

1962
Work is started on the new administration building in Basel, which is now the headquarters of Lonza.

1969
Lonza expands into the United States and lays the foundation stone of the Chemical Specialties Business Unit with the formation of Lonza Inc., Fair Lawn, NJ, and acquisition of a plant producing sorbitol, tertiary amines and quaternary ammonium compounds in Mapleton, IL.

1977
Lonza's first US fine chemicals plant starts operation in Bayport, TX.

1980
Lonza opens the administrative headquarters of its Polymers and Additives Business Unit in Milan.

100 years of progress with Lonza

1984
Production gets under way at the first multi-purpose plants of the new fine chemicals complex in Visp, Switzerland, laying the foundation stone for Lonza's exclusive manufacturing business.

1986
In Williamsport, PA, and Painesville, OH, two plants for the production of fatty acids, fatty acid esters, glycerine, hydantoins and special surfactants are taken over.

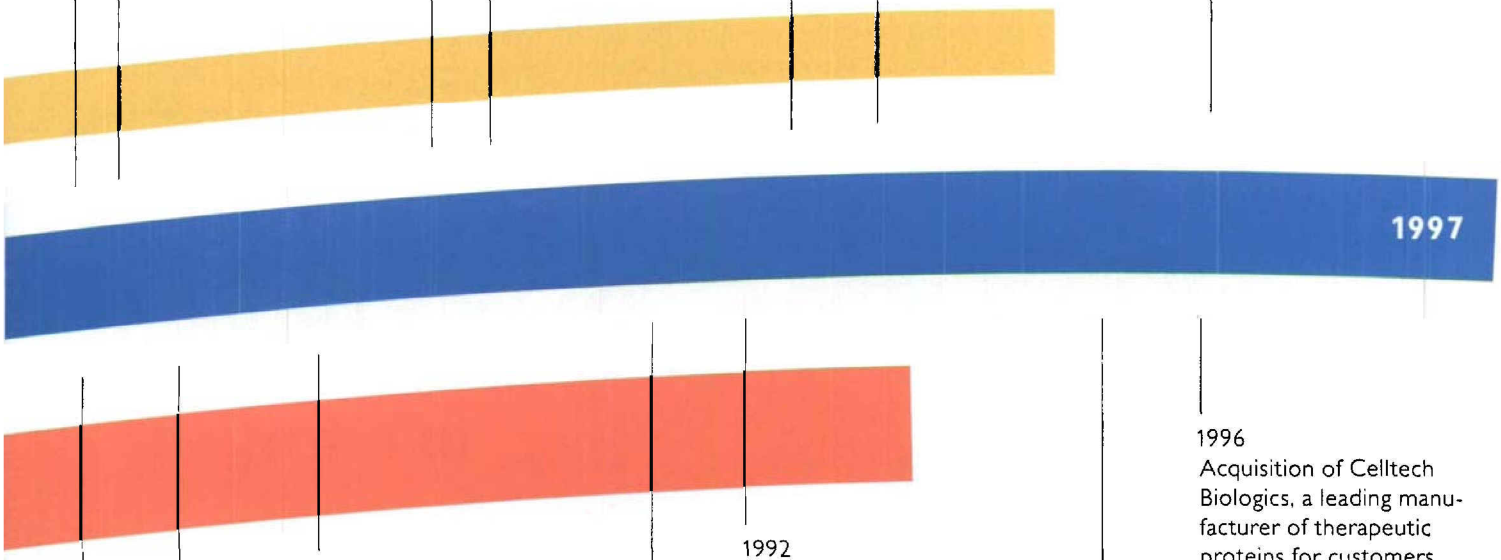
1990
Entry into the thermoplastic technocompounds sector with purchase of Resinmec SpA, Italy, with works in Pontirolo Nuovo and Pandino.

1990
Lonza acquires a manufacturer of pharmaceutical active substances in Los Angeles, CA.

1992
Lonza acquires the Riverside Fine Chemicals plant in Conshohocken, PA.

1994
At the new production site in Ravenna, Italy, the world's most modern maleic anhydride plant comes on stream.

1996
Lonza signs a joint venture agreement for the construction of an isophthalic acid plant in Singapore, setting a further milestone in the expansion of its operations in Southeast Asia.



1985
Acquisition of Molding Compounds SpA in Brembate Sopra, Italy, a company producing SMC and BMC technocompounds.

1990
Takeover of Reglar Srl, Scanzorosciate, Italy, producer of SMC and BMC plastic semis.

1990
The Chemical Specialties Business Unit expands its research and application technology activities, moving into new research facilities at Clinton, NJ.

1991
Purchase of Duroform GmbH in Miehlen, Germany, a manufacturer of SMC and BMC plastic semis.

1992
Lonza expands into Central Europe with the purchase of Biotec sro, Kouřím, Czech Republic, a company specializing in biotechnological production of fine chemicals.

1995
Lonza lays the foundation for expansion of its operations in the Asia-Pacific region by signing a joint venture agreement for the construction of a niacinamide plant in southern China.

1996
Acquisition of Celltech Biologics, a leading manufacturer of therapeutic proteins for customers from the pharmaceutical industry. The company has a research and production center in Slough, GB, and a new plant in Portsmouth, NH, USA.

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