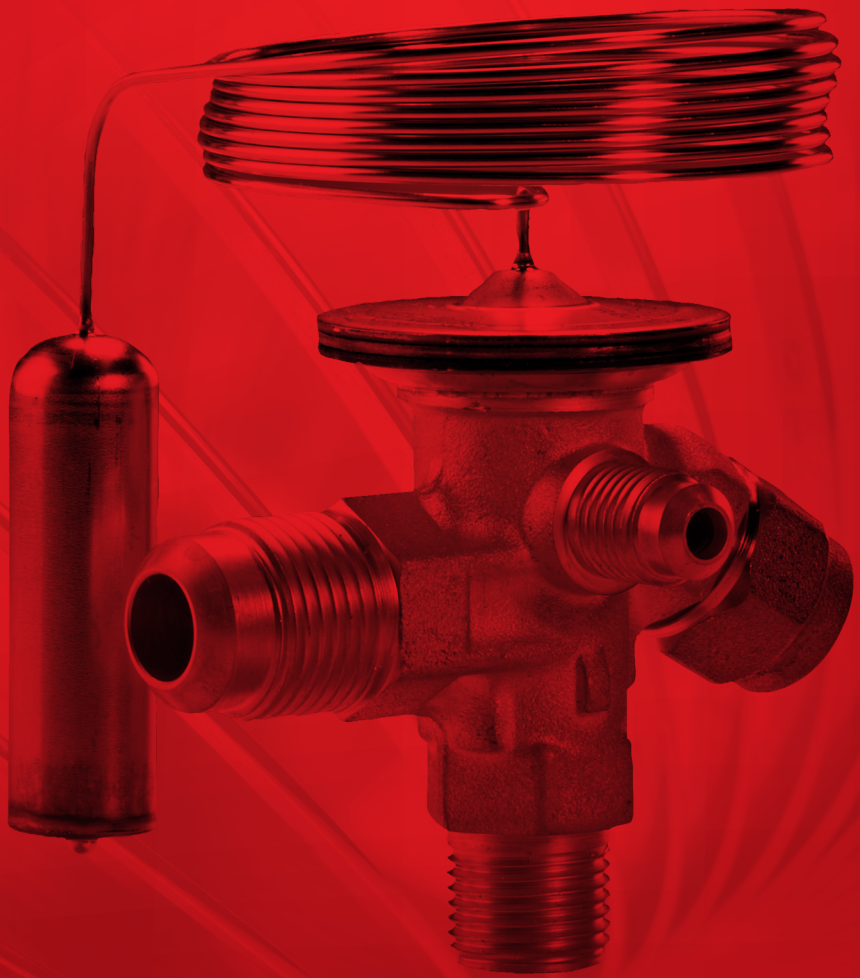
ENGINEERING
TOMORROW

The Golden Egg from Danfoss



The Golden Egg from Danfoss

Published by:
Danfoss A/S

ISBN:
ISBN 978-87-998907-0-5

Text:
Trine Kiær, Danfoss A/S

Layout and DTP:
Jonna Neumayr, ColorSigns

Print:
Grafisk Arbejde, Guderup

Translated by:
TextMinded A/S

The Golden Egg from Danfoss
First edition
The book is available as e-book
on www.danfoss.com

Printed in Denmark 2016.

A Genuine Industrial Fairy Tale

In the film industry a sequel is often worse, and everything that captivated us in the initial film seems watered down in the sequel. This is not the case with the T2, the thermostatic expansion valve from Danfoss. Before the T2, there was a TRV and a TVJ and a great number of other valves, but none as good as the T2. It is the T2 that - to date - is the greatest success in the refrigeration and air conditioning business at Danfoss.

In 2016, the thermostatic expansion valve celebrates 50 years and, concurrently, Danfoss will set a milestone record when the 50 millionth T2 valve rolls through the assembly line in Nordborg, on the island of Als. It will take place in Southern Jutland in Denmark, only a stone's throw from where the founder of Danfoss, industrialist Mads Clausen, developed the first valve in 1933 and founded Danfoss, then called the Danish Refrigeration Controls and Apparatus Manufacturer. But even though the fairy tale of the small T2 valve started in Denmark, there is hardly a refrigeration system in the world where this valve does not play a key role, for all types of commercial refrigeration. Though it is not a prominent and visible component, usually well- hidden to the naked eye, it is nonetheless the most important function as the heart of the refrigeration system. Here it is used for liquid injection into the evaporator of the refrigeration and air conditioning system - exactly like the valve Mads Clausen developed in 1933 - based on the same principles, but challenged by demands for new fillings, materials, environmental laws, welding techniques and new working processes.

Congratulations to everyone who is working, or has worked with, the T2, and thanks to everyone who agreed to be interviewed and took the time to tell the story of the valve, which was first called *The Ugly Duckling* and *The Outboard Engine*. The T2 ended up turning into a beautiful swan, and for Danfoss, the T2 will always be a Golden Egg.

And last but not least, congratulations to the T2, which functions as the heart in millions of refrigeration systems worldwide and ensures proper cooling of food and indoor comfort - and refreshing, delicious ice cream on a summer day.

1949

If you can find anyone lazier than you, you can shoot him!

Knud G. Hein – the man behind the first T2 valve

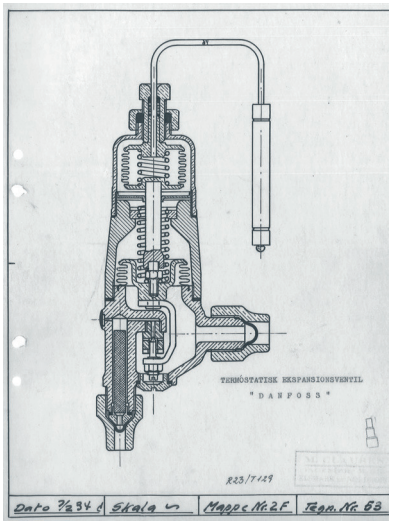
The Man behind the Valve

Meticulously, he placed his tobacco to dry on the radiator, turned up the heat, and loosened his tie. His name was Knud G. Hein. That the G stood for Georg was first revealed upon his 25th work anniversary in 1974. But in 1949 at Danfoss, the first and middle names were unimportant. Last names and the formal form of address were used.

Hein lived on Apotekervænget in Nordborg. He was an avid car driver and, wearing a comfortable hat, he liked to drive with the family on vacation to Prague, and on Saturday he dined with his wife at Nørherredhus in Nordborg. When he replaced his little Fiat 127 with a new Morris, he told his colleagues that it was only four millimeters wider than his old car, otherwise it would not fit in the garage. He had a propensity for detail. Hein had a temper and became angry when projects failed, but had he lived today, he would surely have been proud that Danfoss has produced 50 million T2 valves in the course of 2016. Because even though many people have worked on the development of the T2 valve, it is still Hein who is the man behind the valve.

In Hein's office, the air was thick from the smoke of fat cigars. He sweated and slaved over the drawings, and notes were scattered everywhere. Hein had his own office, since he disliked noise. Grand ideas were born here, and Hein often sat and gazed out of the window. This was noticed by management, and a supervisor shook Hein, shouting: "If you can find anyone lazier than you, you can shoot him!"

This got things rolling.



Drawing from 1934 of the TRV – the precursor to the T2 valve.

Cigars and a comfortable hat characterized an engineer at Danfoss.

1950

Expansion valves from the first factory in Elsmark, Nordborg, 1943.

The Dictaphone

Between 1952-53, industrialist Mads Clausen traveled to the United States and brought a dictaphone along. It followed him everywhere, and when he saw something interesting he made a recording on the dictaphone. He also interviewed employees, supervisors, and competitors. Wherever Mads Clausen asked questions, he got answers. This would be unthinkable today due to competitor and industrial anti-trust laws, but Mads Clausen was allowed to research and visit companies all over the United States. He also took notes diligently. At that time, the United States was the frontrunner, and it was important to bring all the wisdom back home.

At the same time, Hein was sent to Mexico to open a new factory. He had to negotiate with the Mexicans, and many have later asked how he accomplished this, since he could not speak a word of either English or Spanish. Presumably he received help from other Danes in Mexico. Hein returned to Denmark after a year in Mexico, and perhaps it was this journey which inspired him to bring the long-awaited valve to the forefront.

Industrialist and founder of Danfoss with the first valve, which started the great industrial fairy tale at Danfoss. The valve is called the TRV and can be seen at the Danfoss Museum in Nordborg. ▶

lx MODERN REFRIGERATION September 1950

Danfoss

AUTOMATIC CONTROLS AND EQUIPMENT FOR REFRIGERATION

Main Dealers :

AUSTRALIA
Refrigeration Supplies Pty. Ltd.
Sydney

CANADA
Automatic Control Devices
Toronto

INDIA
Larsen & Toubro Ltd.
Bombay

NEW ZEALAND
J. Russell Hancock Ltd.
Wellington

KENYA
Transcandia Ltd.
Nairobi

SOUTH AFRICA
RHODESIA
J. L. Clark & Co. Ltd.
Johannesburg

UNITED KINGDOM
Dean & Wood (London) Ltd.
London

on sale anywhere in the

UNITED KINGDOM AND DOMINIONS

Danfoss Manufacturing Company

Factory and Head Office · Nordborg · Denmark
Telephone · Havnbjerg 5411 · Cable Address · Danfoss · Nordborg
Telex No. 3288

Printed for the Proprietor of MODERN REFRIGERATION, Empire House, St. Martin's-le-Grand, London, E.C.1, by H. R. GRUBB, LTD., Croydon.

Advertising from 1950 for the TVJ valve. The TVJ was produced from 1948 to 1967. The TVJ valve was the direct precursor of the T2 valve. Production of the TVJ was stopped when the T2 was introduced to the market. The first generation was the TRV, the valve with which Mads Clausen founded Danfoss. The second generation was the TVJ, and the third generation is the T2.

A 48 E - 100

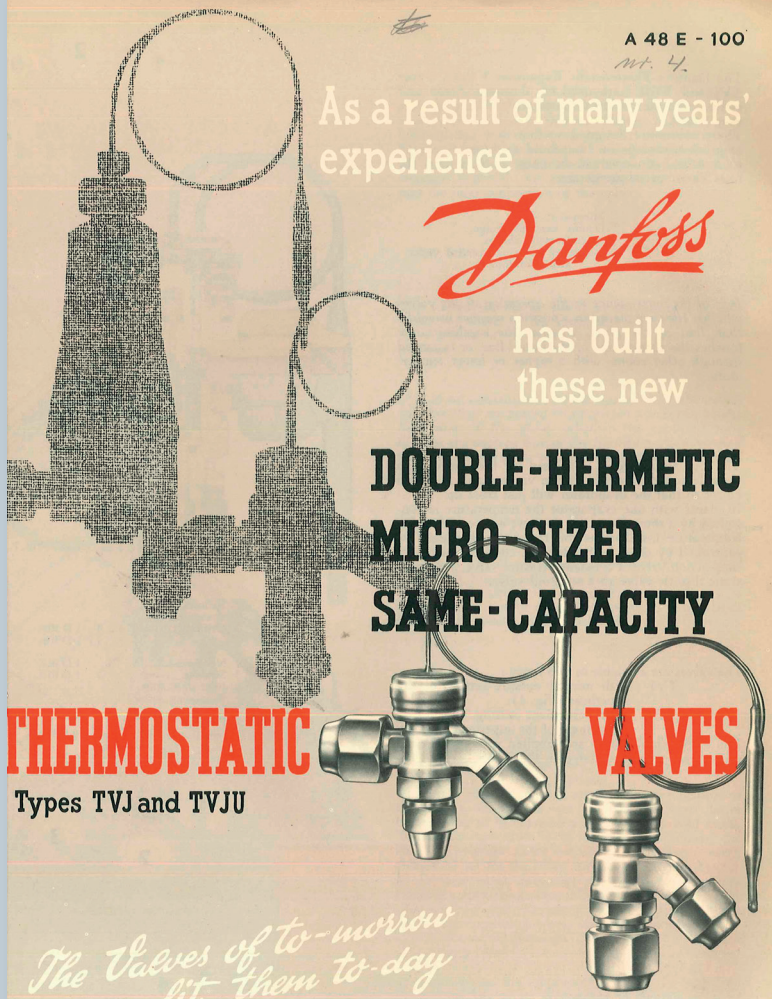
Nr. 4.

As a result of many years' experience

Danfoss

has built these new

DOUBLE-HERMETIC
MICRO-SIZED
SAME-CAPACITY



THERMOSTATIC VALVES

Types TVJ and TVJU

The Valves of to-morrow — fit them to-day

1957

Svend Carl – one of the many engineers who arrived on the island of Als to work with the T2 valve. Photographed in New York.

Maritime Chief Engineers Land on Als

At the end of the Fifties, Danfoss employed many maritime chief engineers. They were used to tackling refrigeration systems on-board ships, they were famous for their loyal relationship with machines, and they were adept at repairing virtually anything. One of these chief engineers was Svend Carl. He used to sail back and forth regularly on the Esbjerg-Harwich line, but Svend Carl chose to start at Danfoss in 1959. He worked closely with Knud G. Hein on the development of the first T2 valve. He never sailed again since he remained at Danfoss for 35 years.

Along with the maritime chief engineers came nicknames; since many had the same last name, such as Jensen and Petersen, nicknames cropped up to avoid confusion. There was Apotekeren (The Pharmacist), Skawbo (The Skagenite), Opfinderen (The Inventor), Jern-Henrik (Iron Henry or Dennis the Menace) – some fairly bawdy and others more subtle. For example one employee was originally Petersen, but he was given a new name: Porland. Perhaps a clever reference to Sporlan, one of Danfoss' largest American competitors, which today is known by the name Parker. ▶

Svend Carl was on board Tilda Dan, a vessel from the shipping line J. Lauritzen. Pictured: Saint Lawrence River, Québec, Canada.

> *The employees we had met did not know my abilities in a workplace on land, because of course I had been a seafarer.*

▶ In the 1950s, there were around 50 engineers at Danfoss. The engineers did not go home until the machine purred like a cat, and this was no different for the then 25-year-old Kaj Ohlsen from Gråsten, Denmark. Kaj was employed as an engineer on a steamship in the East Asiatic Company, but a visit to Danfoss led him to change course.

He had been out sailing for 14 months and had previously been on board the Royal Danish Yacht, Dannebrog. Before the long trip, he had been engaged to be married. His fiancée was not so thrilled about having to be without him for so long, but Kaj believed that the future was at sea. Nevertheless a friend convinced Kaj that he should apply for a job at Danfoss:

"One evening, we were in the city and met another fellow from Gråsten who, like myself, was a trained engineer. He had started working at Danfoss and was certain that they could find me a job. I was persuaded to try, so in my best school penmanship I prepared a letter that was immediately sent to Danfoss. A few days later I received an application form. I completed it to the best of my ability, but under the heading "What sort of work are you looking for?" I fell short and wrote that I did not really know, as I was not aware of what Danfoss was doing. This was a perhaps also consistent with the fact that I still had the urge to sail.

Kaj Ohlsen got a job in the sample production department as assistant production supervisor. It was a relatively new department under the management of Carl Raun, who gave Kaj Ohlsen the first mandatory guided tour of the factory. After the guided tour Carl Raun mentioned a few things that surprised him. In the application form there was one question: Do you know anyone at Danfoss?" Carl Raun now wanted to know why Kaj had answered no to the question:

The seaman Kaj Ohlsen who dropped anchor at Danfoss and stayed for 36 years. Kaj died in the autumn of 2015, but managed to recount his experiences at Danfoss.

"I replied that the employees we had met did not know my abilities in a workplace on land, because of course I had been a seafarer. But I rather think it is likely that it was due to my lukewarm attitude to the job on shore when I filled out the application form. In the form I also stated that I had a hearing impairment in my left ear. Carl Raun said that he had deliberately lowered his voice during the tour, but he had not noticed that I had problems hearing.

Kaj Ohlsen came to play an important role for the T2 in the 1970s, and he was at Danfoss for 36 years – until he lost hearing in both ears and chose to leave Danfoss and retire.

1964

The T2's popularity is due in particular to the fact that it was packed nicely into a fine red carrying case where all sizes of nozzles were readily accessible to the installer. ▶

The Soldier and the Little Mermaid

In 1964, the year the Beatles skyrocketed to the top of the charts and the Little Mermaid statue in Copenhagen was beheaded, a young man started working at Danfoss, who many years later would become divisional president of the refrigeration business, Finn Fastrup. He started out in the design department, went to the military and then he joined Technical Function, where for seven years he answered questions from customers from around the world. The department later became Sales and Marketing, since a great deal of marketing and a small carrying case were necessary to present the T2 to the world.


Danfoss
DANFOSS

1966

The Outboard Motor

Mads Clausen created the first valve in 1933, and 33 years later, the T2 was born. "The T2 valve resembles an outboard motor for a small dinghy," said a production supervisor at Danfoss when he first saw the valve. "And it is so small - a little Ugly Duckling." But he did not dare tell Hein, because one did not talk that way to a superior.

Hein was from Randers , Denmark, and trained as a builder, but he always referred to himself as an engineer. Hein's father had a motor factory in Randers, and perhaps because of his maritime ancestors, the valve came to resemble an outboard motor.

Hein previously worked at the design studio in Mads Clausen's childhood home, but moved to his new office at Elsmark 15 in Nordborg, where the designs for the T2 eventually took shape. The T2 was difficult to produce. The machinery had not yet been invented, and the T2 required precise tolerances. This was hard to translate into reality, and it took Hein a long time to set it up. The T2 was Hein's life's work, and in 1966, the valve was ready to be launched.

In January that same year, Jørgen Trelle Pedersen started at Danfoss. Trelle was a mechanical engineer with a passion for geology, which turned out to be fortuitous for the T2 valve. He started in January. Six months later, all of northern Als was dressed in black and in deep mourning since, on August 27, 1966, industrialist Mads Clausen passed away.

Drawing by the previous designer, Svend Carl, who for many years worked together with Knud G. Hein, the man who designed the T2 valve. Hein's father had an engine factory in Randers. Perhaps it was because of his maritime ancestors that the valve came to resemble an outboard motor?

S A L G S P R O M O T I O N

Årsresultat - KØLE

Salget af køleautomatik har i 1966 vist en usædvanlig stigning (4o%), som det ses i nedenstående opstilling.

Mill. kr.	R 1964	R 1965	R 1966	SB 1967	SF 197o
Køleautomatik	48.8	53.4	75.1	78.8	96.4

Afsætningsmæssigt har stigningen dog nok ikke oversteget 33-36%, idet prisforhøjelsen i 1965, som må have hæmmet afsætningen noget, kan antages at udgøre 2-3 mill. kr. af omsætningen i 1966.

Stigningens årsager.

14-16% ud af de 4o%'s stigning tilskriver vi fire forhold under ét: dels en efterspørgselsstigning i Europa på 4-8 procent, dels at vi med den i midten af året begyndende stedfundne forbedring af de ganske uholdbare leveringstilstande, som herskede i 1965, kunne få resultater af en aktiv salgsfremmende indsats, dels det voksende kendskab hos markorganisationen og kunderne til den fremadskridende modernisering af vort produktprogram, og dels en øget anvendelse af prisparameteren til sikring af større ordrer.

4-6% ud af de 4o% tilskriver vi den lagerstigning, som har fundet sted hos forhandlere og afdelinger udover hvad der var nødvendigt for at tilpasse lagrene til det højere omsætningsniveau. En del heraf må forventes nedbrudt igen.
6% fremkommer ved overførsel fra S-varmes statistikker af visse RT-typer.
Ca. 1o% tilskrives de nye salgsorganisationer, som er etableret i Japan, Australien, Grækenland og Spanien.

Ca. 4% skyldes særlige latinamerikanske forhold.

Resultatet i de geografiske områder.

I Vesteuropa er salget steget med ca. 28% fra 37.4 mill. kr. til 47.9 mill. kr. (Regnes Spanien ikke med, bliver stigningen ca. 23%).

I Østeuropa er salget steget med ca. 3o% fra 7.9 mill. kr. til 1o.2 mill. kr.

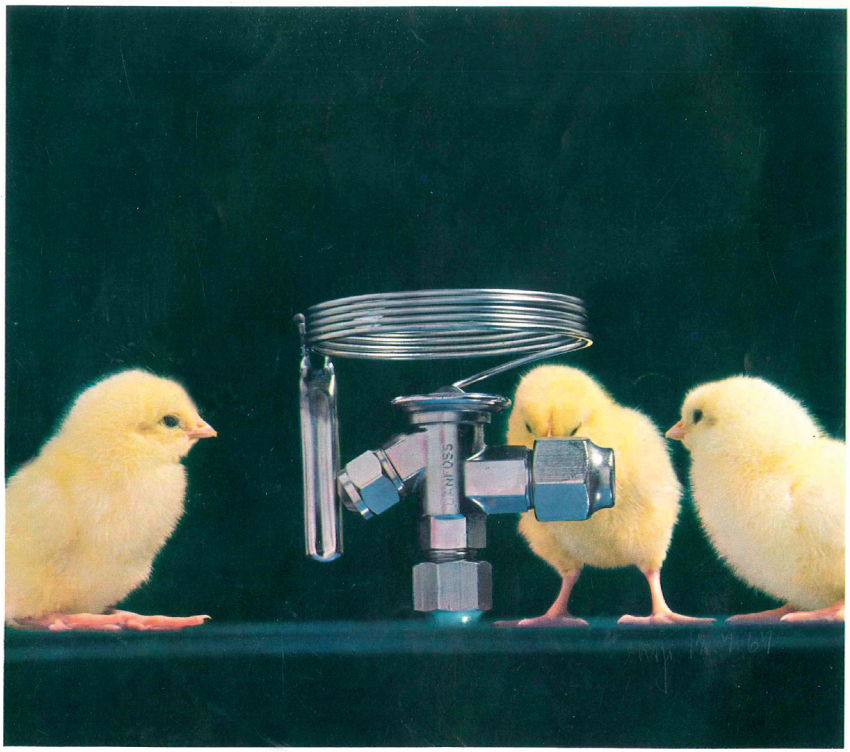
Salget i Sydamerika er igen kommet op på ca. 4 mill. kr. efter i 1965 at være faldet til 2 mill. kr.

I de førnævnte lande, hvor Danfoss har reorganiseret sig - Japan, Australien, Spanien, Portugal og Grækenland - er salget steget med ca. 12o% fra 5.3 mill. kr. til 11.7 mill. kr.

Resultat pr. produktklasse.

Produktklasse	Typer	S 1965	S 1966	SB 1967
1	Termoventiler	13.3	17.6	21.4
2	Sugetryksautomatik	4.6	6.2	5.8
3	Magnetventiler	12.1	16.2	16.o
4	Vandventiler	2.6	3.1	3.o
5	Håndafsp- ventiler	2.2	3.4	3.4
6	Termo- og pressostater	13.1	2o.3	21.o
7	Hygrostater	o.2	o.3	o.2
8	Tørrefiltre etc.	4.o	5.1	5.3
9	Diverse	1.3	1.8	1.8

Excerpt from the sales report of 1966. In 1966, the T2 was really beginning to gain a strong foothold in the global market. Sales exploded, or as stated in the annual report: "In 1966, sales of refrigeration controls have shown an unusual increase (40 %). A part of the success was attributed to an active promotional effort and the growing knowledge of the progressive modernization of the product range." In the financial statements, the T2 plays a crucial role, with sales increasing by 120% in Japan, Australia, Spain, and Portugal, from DKK 5.3 million to DKK 11.7 million. The T2 was well on its way to conquering the world.



...take a look at these advantages

Danfoss thermostatic expansion valve Types T 2 and TE 2 - a small valve with great features

Danfoss

- Large capacity, small dimensions, rapid response
- Wide temperature ranges:
  −40° - +50°F (−40° - +10°C)
  −67° - −13°F (−55° - −25°C)
- Space-saving 90° angle-way connection - large flats, easy fitting
- Optimum utilization of evaporator
  5 valves in one - interchangeable orifice assembly
  Easy adjustment within a wide range
- Fricorr® natural stone needle
- Is not affected by hot-gas defrosting
- Short double contact bulb (Patents Pending)
- Internal or external pressure equalizing
- Diaphragm design. Test pressure 377 psig (26.5 kg/cm²)
- Refrigerants R 12 and R 22

Special pamphlet 68-. 3. 02. 02

DEAN & WOOD LTD.
83/85 MANSELL STREET LONDON, E-1

68-. 6. 02. 02/01

International advertising from 1968 for T2 and TE2.

1970

It's true – and we can't do anything about it!

The Steadfast Engineer

In 1970, Kaj Ohlsen took over responsibility for the new thermal valve T2. The new valve caused major problems. The welding was unstable, delivery of items was unreliable, and a staff shortage also played its part:

"There were not enough production supervisors and we operated three shifts with a production supervisor on all shifts. At the time I discussed the situation with our senior production supervisor. He was known as a very competent supervisor of thermal valve assembly, but unfortunately most of his skills were in the area of troubleshooting products, not administrative tasks. At the same time, he had difficulty cooperating with our department manager. The chemistry was too disparate," said Kaj Ohlsen.

In a discussion with management, Kaj argued that the department stood on the brink of being run into the ground. The department manager agreed with Kaj, but said that he could get his solution proposals through, which greatly upset him:

"I was given the opportunity to have a meeting with the department manager. There I conveyed in a slightly agitated way my opinion about the department's challenges. The manager listened, but as usual did not say anything of note. A couple of days afterwards he called back and asked me if I was an engineer. I said yes. I suppose I thought that he was about to get me transferred to another department. A couple of days later he called again and asked me to a meeting in his office. There he offered me the position of production supervisor for all the new thermal valves, but only as acting supervisor so that he could see if things were working out in six months' time. It seemed to be a rather strange arrangement, but I was given the opportunity to think about the offer for a day."

Torben Matzon and Kaj Ohlsen at L3 in Nordborg.

Kaj ended up accepting the job, and he was allowed to employ two new production supervisors, which were needed for the tasks to be properly performed. After a number of months, Kaj had a special experience when the department manager wanted to increase production of the T2:

"I listened a bit in a state of disbelief and quickly broke in with the remark that it was a bit of an illusion, given that the absence of items and materials for current production was the biggest problem right now."

The department manager looked at him, wondering yet again what Kaj Ohlsen had observed. But he simply needed to sit back and listen, as Kaj had prepared himself thoroughly.

"Fortunately, I am good at figures, so I was able to come up with many concrete examples. One of the biggest problems was the lack of delivery of agate needles from a company in southern Germany. I counted up the design numbers and figures, and even almost 40 years afterwards, I can still see the planning manager throwing his pencil across the table and exclaiming, "It's true – and we can't do anything about it!"

Thanks to Kaj's numerical skills, he was promoted again soon thereafter. This time he was appointed senior production supervisor - and not just acting - but on a permanent basis.

1974

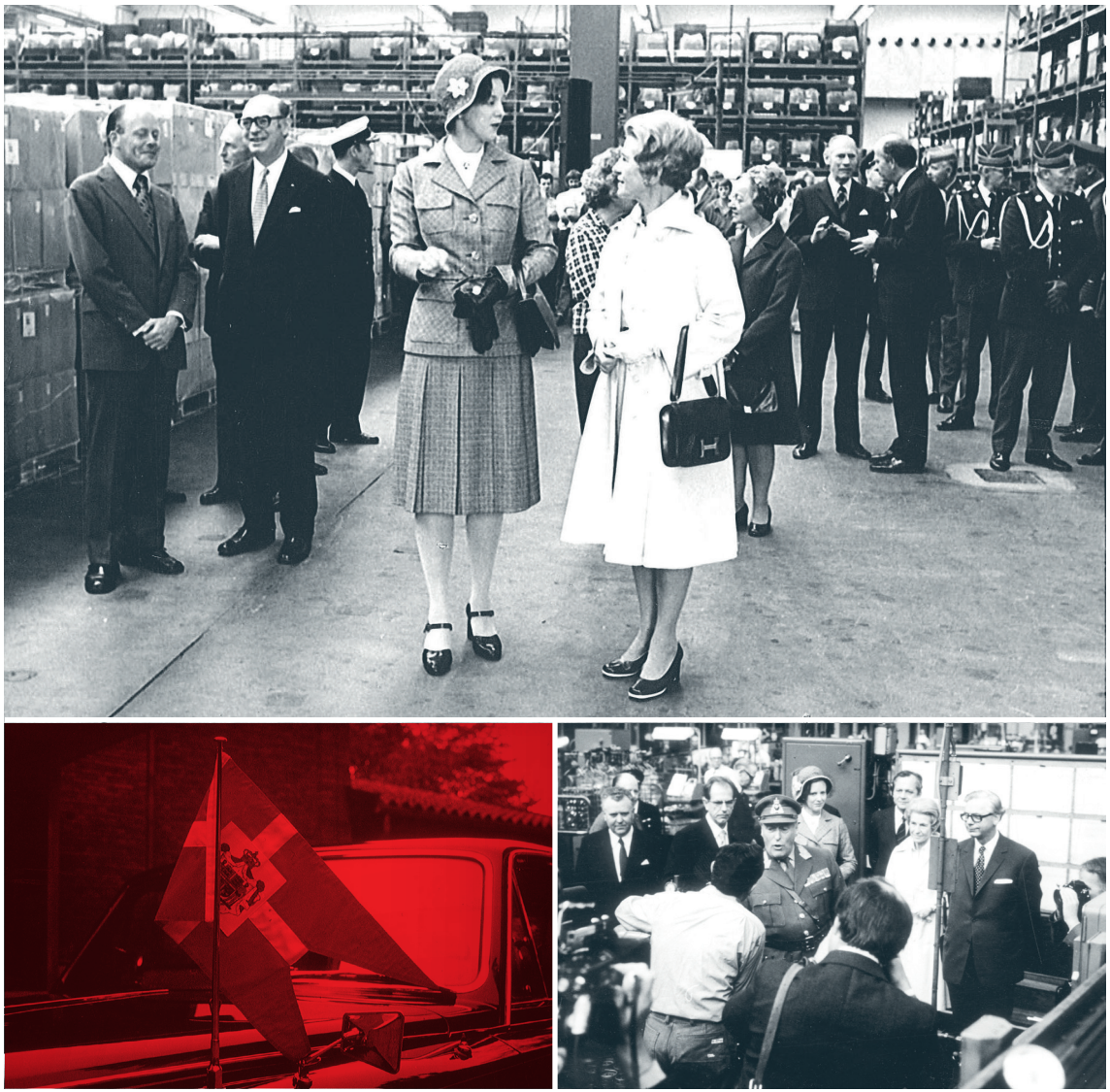
In 1974, engineer Knud G. Hein celebrated his 25th work anniversary. In this picture, Hein is receiving his bonus from his supervisor, Egon Nielsen (left).

Relocation

In 1974, the oil crisis lifted, and Danes could once again drive their cars on Sunday. The royal family also resumed travel activities, and in 1974, Queen Margrethe of Denmark and King Olav of Norway paid a delightful and well-orchestrated visit to Danfoss.

With increasing production lines and increased space requirements, several productions were moved first to Aarhus and later to Kolding, where Danfoss opened a new factory in 1974. But the T2 remained in Nordborg, and in time, much of the craftsmanship that had previously been connected to the valve disappeared.

Together with the joint forging department, solenoid valve production moved to Kolding, which at that time was based on Ellehammervej. Here they continued to forge the valve housing for the T2, while the actual processing of the valve housing remained at L3 in Nordborg.



King Olav of Norway and Queen Margrethe of Denmark visiting L3 in 1974, accompanied by the Manufacturer Bitten Clausen and members of the Executive Board.

1978

The Only Rooster in the Barnyard

Svend Stuhr Jepsen today works as a product expert with primary responsibility for the T2. He came to Danfoss in 1978 as a technical designer in the studio for refrigeration valves. When Svend was employed at Danfoss, the designers working in the studio were all female, and they had to accept that *the new designer girl* was a man.

Svend Stuhr Jepsen said, "The designing studio was a large space where there were 10-12 engineers and technical designers. I was the first male designer, and this resulted in several comments, since most had expected that a girl would waltz through the door.

Part of my job was to take care of the external telephone, and to act as switchboard operator. We were colleagues on a completely different level at that time. Today we run into each other in the hallway all the time. Back then we did not. Our functions worked very separately. Aside from those colleagues, sitting in a room together, we only saw other colleagues from other departments if a meeting had been arranged.

One of the design studios was called *the burial chamber*, because it was always dead quiet in there. It was not like that in our studio, but it was generally quieter at the workplace than it is today. We were probably less stressed back then, and when the central phone rang, we all listened anxiously wondering - who was this call for?"

Gradually, as all employees were given their own telephone, there was more bustle in the studio:

"After the arrival of the telephones in the 1980s, the design studio became a livelier place, with more young employees of both genders. The 80s were in many ways a goodbye to the burial chambers, but also a kick-off to the wild hunt for filling materials for the T2."

1980s

Production employee Anita Nissen in the 1980s in the process of fitting the T2 valves.

From Unruly Teenager to Swan

In the 1980s the T2 valve went through numerous changes due to increased environmental and energy targets, for example from the 1987 Montreal Protocol. For the T2 and Danfoss, it meant the requirement of switching to new refrigerants. Anders Vestergaard started at Danfoss in 1980 as a tool designer, and is currently head of production technology. According to Anders, the 1980s were the most important years for the T2.

"The T2 went from being an unruly teenager, who was out of control, to being more mature and more reliable as well. The need for change was because the valve had a very volatile lifespan of the membrane element, and so we had great difficulty in managing and controlling the plasma welding process."

Due to the many new refrigerants that came as a result of the Montreal Protocol, a smart and flexible charge mixture was developed. Now all charges are made by changing the mixture ratio in the two charge media.

"In the good old days, when there were only a few refrigerants, they all had their own color code, and during production, a data label containing the valve's refrigerant color was placed on the valves. An R12 valve got a yellow label, an R22 a green one, etc. When numerous new refrigerants appeared, this solution became cumbersome and inflexible. It took a long time to obtain new labels, which were prepared by a subsupplier. In 1994, when the "Langelinie" – the long T2 production line - was established, these labels were abolished and replaced with laser

> *It was in the 80s, when we "tamed" the wild teenager, as the T2 was at the time, and it was in this decade that it transformed into a swan.*

"In a way, I follow in both Hein's and Mads Clausen's footsteps as thermal valve designer. However, there is a significant difference: I have not smoked as many cigars as them." Anders Vestergaard in Beijing with a good cigar.

engraving directly on the valve's stainless cover. It relieved the complicated work with the labels," said Anders Vestergaard.

In the mid-1980s, Danfoss conducted a project under the name *The T2 High-Pressure Element*, where the membrane element's strength and life were improved significantly.

"In 1988, we found further improvement of the membrane element when we transitioned to laser welding. I remember that when I started, there were constant problems with the membrane lifespan. The design was not robust. The membrane material was not always in order and the welding process was often out of control. But we took control of the T2 in the 80s. The work at that time gave me a good ballast for working with construction and later with thermal valve design and projects. But it was in the 80s, when we "tamed" the wild teenager, as the T2 was at the time, and it was in this decade that it transformed into a swan," said Anders Vestergaard.

1980

The Wild Hunt

"In 1980, asbestos was banned in Denmark and in a number of other countries because it is a carcinogen," said Jørgen Trelle Pedersen, former mechanical engineer, known as Trelle.

"Asbestos had many applications, such as asbestos cement roofing sheets, tubes, pipes, brakes and clutch pads in cars, sealing materials for flange joints, packing material for heat insulation of boilers and ovens. A negligible amount of packaging material was used as so-called thermal ballast in the T2 valve sensor. The purpose of the thermal ballast was and is to extend the sensor response time for increasing temperature and to maintain the short reaction time for falling temperature. The oscillations are, thereby, suppressed in the evaporator and the compressor is protected from liquid hammer. The ballast was just a piece of asbestos gasket as the material was cheap and easily accessible."

The asbestos ban led to a wide range of replacements for sealing materials entering the market.

"The studio started a series of tests in the refrigeration lab, but it did not go very well. The tests were conducted by Vladimir Decovski, and after about half a year of fruitless work, he was to say the least, somewhat frustrated," said Trelle.

Jørgen Trelle Pedersen with the moler bricks from his old house on Als. ▶


R134a

1981

The first moler brick used as ballast.

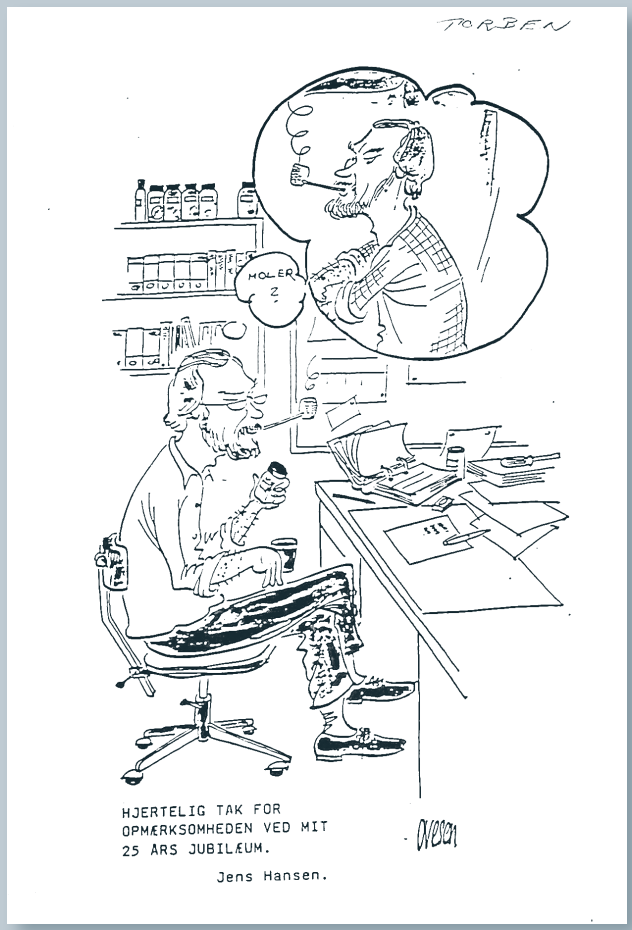
The Magic Stones

Vladimir Decovski's frustrations led Trelle proceeding to analyze the characteristics that the thermal ballast should have. These were: 1 – high porosity; 2 – low thermal conductivity; and 3 – good temperature resistance. Points 1 and 2 provide the desired function, and point 3 was necessary because the sensor had to be soldered together after the ballast was loaded.

Various materials were considered - and again rejected – for various reasons, such as the material only being available as a powder. An old book on gas chromatography would prove to be an important source of inspiration for Trelle. On Mors and Fur in Limfjorden, sediments of moler were found, which in practice is the same as diatomite, both predominantly consisting of microscopic silica shells from unicellular algae. From the moler, bricks were baked, which had high porosity, low thermal conductivity, and high heat resistance.

Trelle thus pondered whether moler brick could be used as ballast. During a remodeling of Trelle's old house, he found some moler bricks from a previous reconstruction:

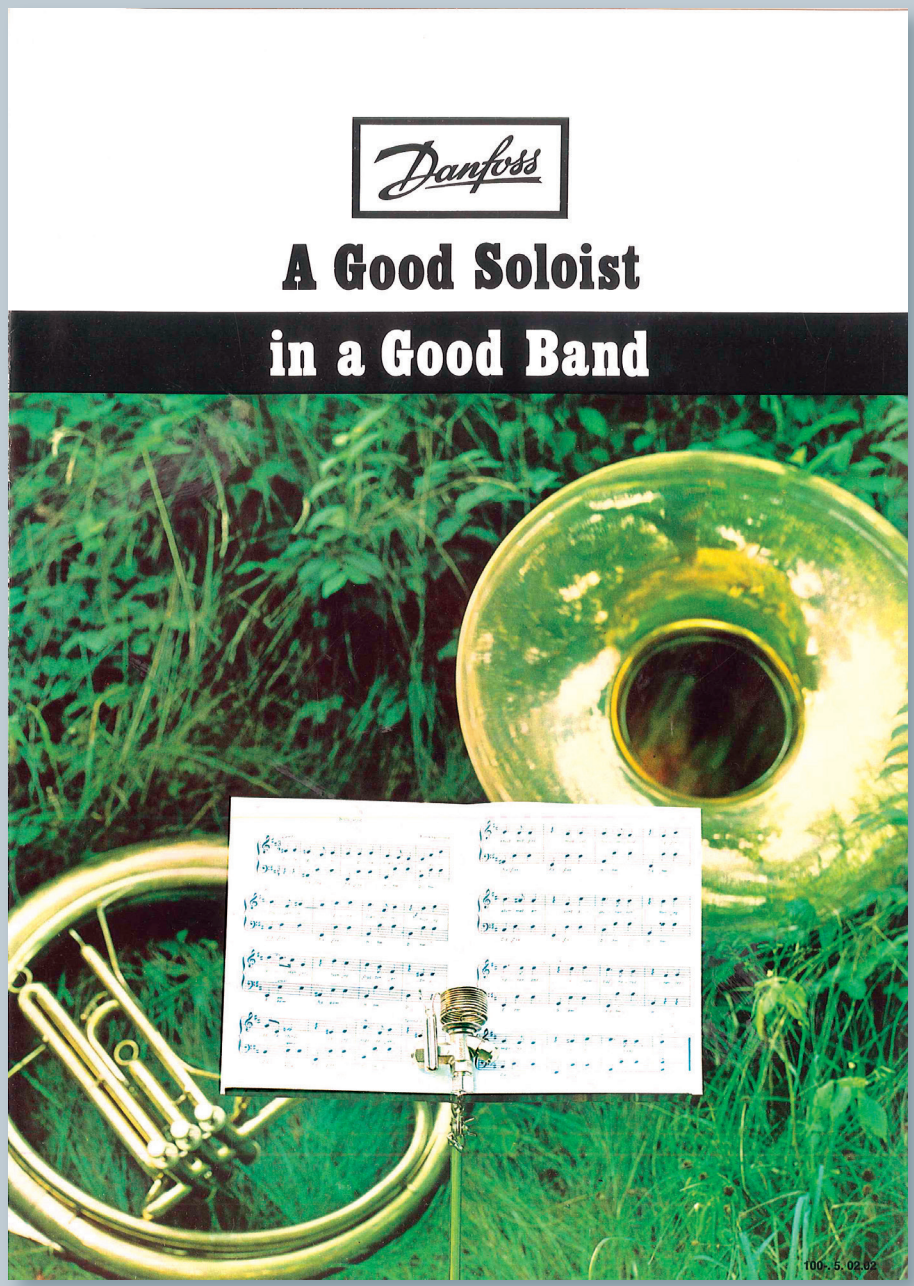
"They had been kept in case they could be reused. One of the bricks was cut into suitable pieces and mounted as thermal ballast in a few T2 valves, which were entrusted to Decovski for testing. The next day, Decovski beamed like a little sun. The valves functioned almost like valves with asbestos ballast, and after some minor changes, a satisfactory function was achieved. The next step was passed along to Jens Hansen at the design studio. They managed to get the company,



Anniversary design from Jens Hansen's 25th work anniversary, when moler still played a significant part in T2 production. Jens Hansen liked to sit with his legs up on the table while smoking a pipe. When asked what he was doing, he replied, "I'm sitting and reflecting."

Skamol, which otherwise mostly dealt with bricks and kitty litter, to produce thermal ballast in the form of oval mini moler bricks that would fit into the T2 valve sensor," Trelle recounted.

Like so many others at Danfoss, Jens Hansen was also an engineer. At that time they only made changes to the T2 if it was deemed essential, and in 1982 he inherited the challenge of the T2 from Trelle.



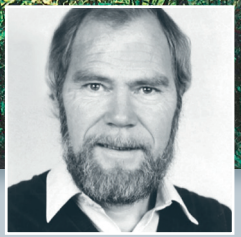
Jens Hansen was employed as a product monitor, and he was active in the Danfoss Orchestra, where he played trombone. His great love of music spilled over into department meetings, where Jens Hansen would bring a suitable songbook, and when they were not discussing the T2, they would sing out loud with the assistance of this songbook. It created a nice atmosphere, and perhaps it rubbed off on marketing, which in the 1980's marketed the T2 with this advertising.

Each instrument of the complete refrigerating programme is an individual Danfoss product of a uniform high quality designed to work alone — like the soloist — or in an ensemble with other instruments — like the band.

Behind the product and the global Danfoss organization there is a large factory with extensive knowledge and experience of automatization of refrigerating plants which can offer you advanced technical advice and information.

Danfoss offers a complete up-to-date programme developed in close accordance with the most rigid demands of the market to ensure optimum utilization of the refrigerating plant.

Soloist - or ensemble - the Danfoss range is designed to be forward of development - convince yourself - send for our technical literature.



Jens Hansen

1982

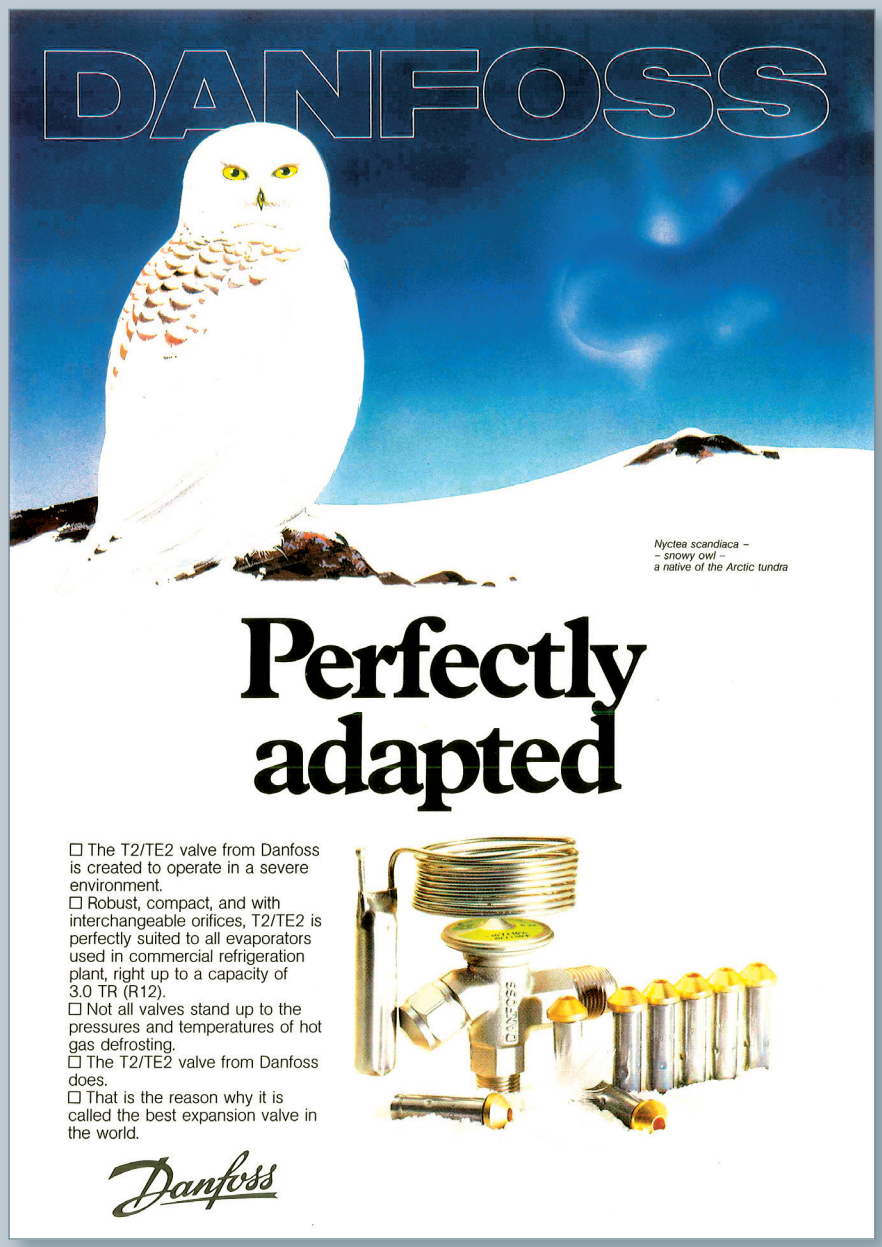
Wherever human beings perform a job, mistakes will happen.

25 Years Work Anniversary with an Eye for Detail

Kaj Ohlsen had a reputation not only for having a head for numbers, but also an eye for detail. By Kaj's 25th work anniversary in 1982, the production director J.P. Blume had a few choice words to say. The production director recounted that when Kaj would walk through the department, he was known for always finding faults and complaining about them. Kaj replied that it was usually easy enough, "Even on a day like today, I have come across some incompetence," said Kaj, and continued:

"The guests were somewhat flabbergasted and they wanted to hear more about it. I had just been handed an aluminum plaque from the chairman of the Association of Engineering Employees, and immediately saw that the engraving of the anniversary date was incorrect. The chairman was pretty upset and demanded the plaque be sent back to correct the engraving. "No," I said, "I'll keep it as proof that wherever human beings perform a job, mistakes will happen." I have this quote from architect Martin Nyrop, who used it during the building of Copenhagen City Hall, when a small pillar was placed upside down to remind posterity that nothing is perfect."

This also applied to the T2, which eventually was flawless, but first it had to conquer the world and convince customers that it was the right choice for them. They succeeded, and the 1980s were a breakthrough decade for the T2.



T2 advertising from the 1980s.

1983-85

The Hessian Jungle

You were considered a computer geek in the 1980s if you were interested in IT. At that time, the first computer terminal to arrive at the design studio for refrigerant valves was stuck in the coat closet. Mostly so as not to disturb the staff who were not working with it.

"We were not computer geeks and to begin with we did not want to be regarded as geeks, so when the new terminal attracted attention, it was relegated to the coat closet. During that first year, we discovered that it was impractical for it to remain in the coat closet, and the terminal was moved into the design studio. Around that time, all the individual work stations in the office were separated by office dividers (called *Hessian Walls*). It was the function-oriented office's first order of business. The new walls created a maze-like atmosphere, and it was harder to find each other in the Hessian Jungle," Svend Stuhr Jepsen explained.

When Svend started his career at Danfoss, there were few modifications to the T2. The valve worked well and there was no reason to change it. Eventually Svend took on the responsibility for the T2 designs and other thermal valves.

"I created designs for product sequels and other small items that needed to be adjusted with the T2, and soon we were moved away from the Hessian Jungle to the large factory building, L3. We needed to be closer to our colleagues in production, and it turned out to be a really good idea. Instead of it just being *us* in the design studio, and *them* in production, it became *us* in L3."

◄ *The computer's arrival at Danfoss was not met with enthusiasm from all employees.*

1986

Finn Fastrup

»Jubiläumsausgabe«

The Flying Trunk

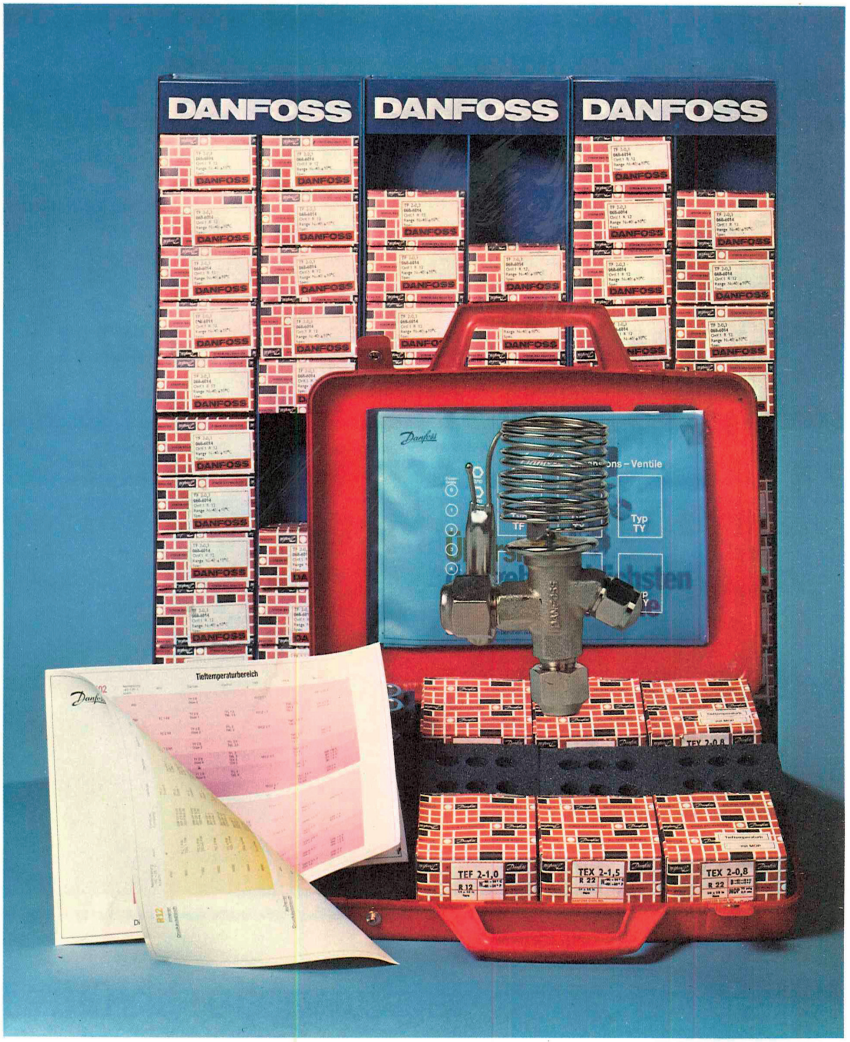
The customers were skeptical. Even though the little valve was more compact, neater, and smarter, many customers still saw it as an ugly duckling. They were happy with the precursor, and there had to be a lot of persuasion to push good quality aside. As for persuasion – Finn Fastrup was a master. An American vendor came up with the idea for attractive packaging for the T2 inspired by an American school lunch box. A fine case that contained all the parts of the installer. Then, Finn went forth into the world with this little case and the customers loved it, leading to a sales explosion.

Even among the Germans, who were initially very skeptical of the T2, sales increased after it was presented at trade fairs. Thanks to the little case – a very simple service kit – the T2 overtook its precursor, and soon they only wanted the T2. Or, according to Finn Fastrup, "No matter how much turbulence there was in the world, and how hard it was to sell Danfoss products, we could almost always sell the T2."

Die komplette Serviceleistung!

- **Service-Koffer**
  - Ventilübersicht
  - Auswahlübersicht
- **Service-Depot**

Danfoss



Example of service case advertising, Germany.

1987

Advertising from 1987 from Kølemessen in Essen. The T2 at that time was already such a success that its competitors began to copy it. Danfoss therefore initiated a campaign with a very clear message: DAS ORIGINAL NUR BEI DANFOSS. (German for "The original – only available from Danfoss"). ▶

The Original

The membrane today is the only part of the T2 valve still manually produced at Danfoss, and it is carried out at The Bellows Factory in Nordborg. All the valve parts come from many different countries: The valve housing is from Italy; the spring is from Spain. The sensor is from Germany, capillary tubes are from France, while the breakwater structures, thrust moler bricks, pads, and the packaging are made in Denmark. The stainless stamped parts and turned brass parts for the valve and nozzle are made in China, and soldering materials come from the United States and the United Kingdom.

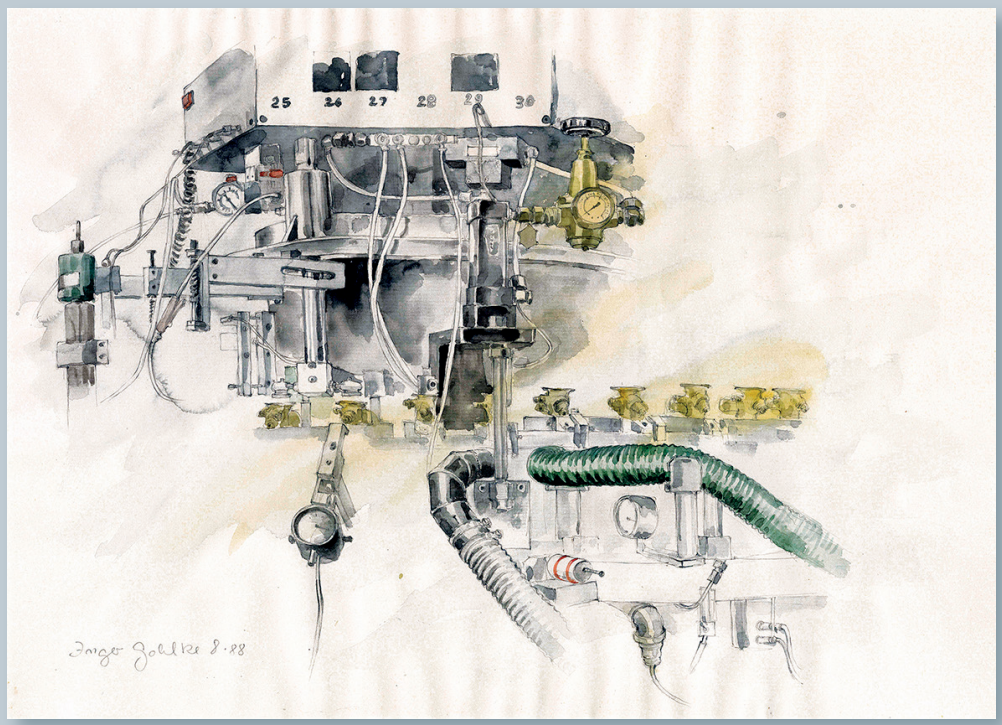
The suppliers have been chosen by the multi-vendor principle, where price and quality are the determining criteria, but in order to create a true copy of the T2, the parts must be found all over the world. This makes it more difficult to imitate, even though many of the competitors have tried, and today there are many imitations of the T2 from our competitors. Therefore in 1987, the marketing department initiated a campaign against imitations, which they called *Das Original* (the original) – precisely to let the market know that there is only one true T2.

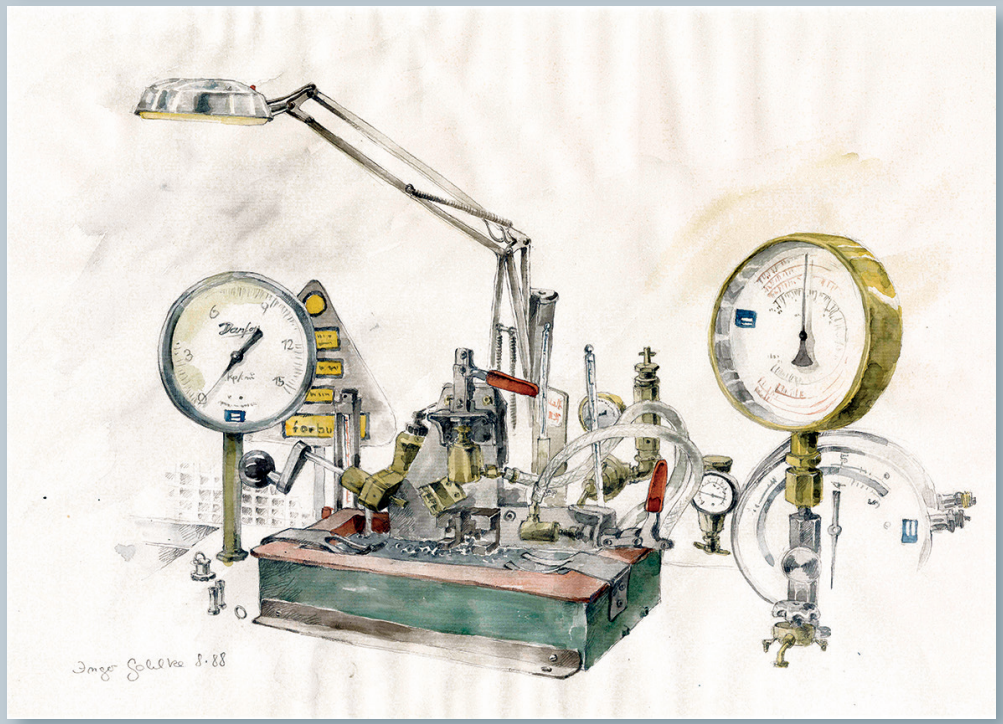
Das Original
nur bei Danfoss

IKK '87
ESSEN
15. – 17. 10. 87

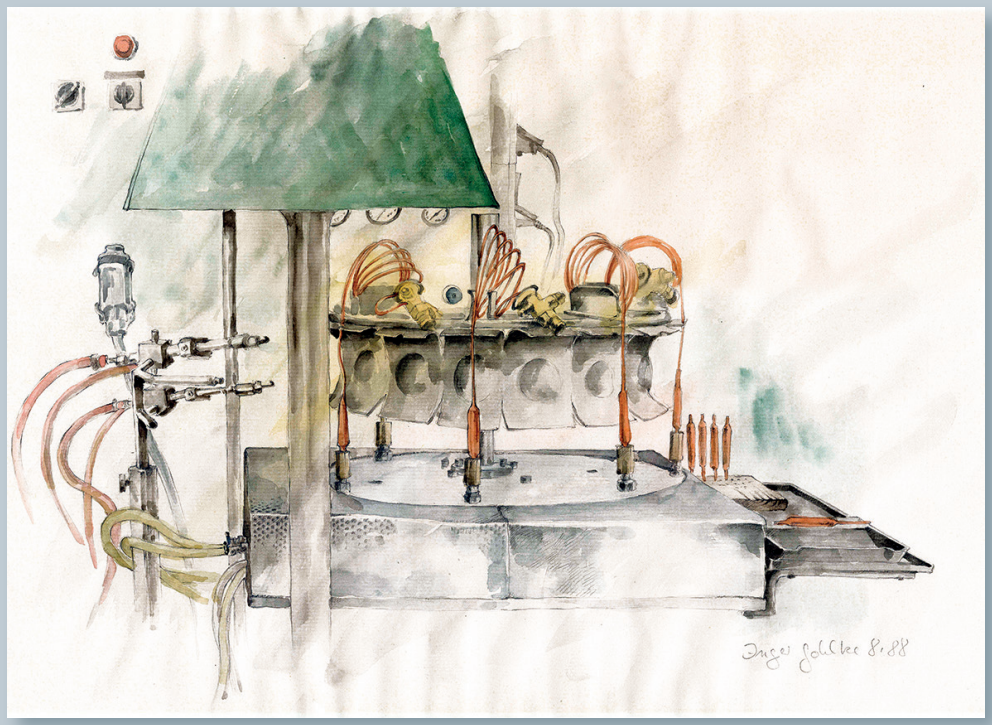
Stand
2022 / 2023
Halle 7

Danfoss


25
26
27
28
29
30


Danfoss

Visual artist Inger Dethlefsen was interested in the industry's raw look, and in 1988, she sat in on production at Nordborg, where she painted watercolors of various assembly lines.



1989

Dan Foss aka Ejner Kobberø Andersen.
Photo of an article in the Danfoss Journal, no. 4, 1996.

Dan Who? Danfoss!

In 1989, a young engineer, Ejner Kobberø Andersen, was sent to New York and New Jersey in the United States.

No one in the United States knew much about Danfoss then, and Ejner Kobberø Andersen thus noticed that customers thought the company name "Danfoss" referred to a person. "Whenever I would call, the customers would say, Dan Who? I would answer DAN FOSS."

Ejner met the T2 for the first time in the United States. He had worked in technical support and said that it was hard to sell the T2 in the United States. "The Americans only wanted valves from the American-based competitor Sporlan, and sales and technical support soldiered on bravely. I was there for three years, and here we used two service cases we called the *Minimizer* and *Maximizer Kit*, containing valves and all the tools needed to install them. We made great efforts for the Americans to start buying the T2. It was a very different kind of valve, and the Americans did not quite understand it. It required a lot of persuasion. Unfortunately, it was never the T2 that turned into the beautiful swan in the United States. This honor fell to the TU-valve, but that is a completely different fairy tale."

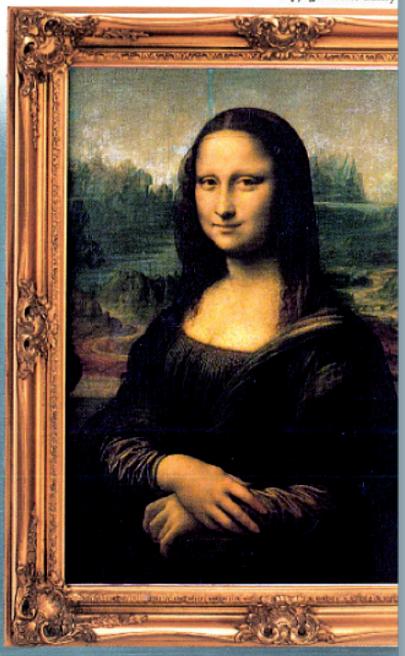
Example of T2 advertising from the 1980s in Sydney, Australia. ▶

MASTERPIECES

To create a masterpiece is something.
To create a masterpiece that works is something else.
Danfoss Expansion Valves — working for you reliably.

P. S. Created by engineers.

EXPANSION VALVE
BY
DANFOSS



MONA LISA
BY
LEONARDO DAVINCI

For up to date information or a discussion contact:

Danfoss

Danfoss (Australia) Pty. Ltd.

Melbourne:
1 Ricketts Road
Mount Waverley
Victoria 3149
Tel.: 03/543 1033
Telex:
AA 34271 Rusarm
Telefax: 03/5434027

Sydney:
199 Parramatta Road
Auburn
New South Wales 2144
Tel.: 02/648 4982
Telefax: 02/7480573

Brisbane:
32 Billabong St.
Stafford
Queensland 4053
Tel.: 07/356 7911
Telefax: 07/3525052

Perth:
52A Fairbrother Street
Belmont
Western Australia 6104
Tel.: 09/478 1566
Telefax: 09/2778457

Adelaide:
58 Richmond Road
Keswick
South Australia 5035
Tel.: 08/371 0422
Telefax: 08/3710907

1990s

Take care of L3, it has always been close to Mads' heart.

Bitten Clausen

The Spirit of Danfoss

In the 90s there was a special spirit at L3 in Nordborg.

"Enthusiasm is contagious, and that was noticeable high up in management. Factory hall L3 was a showcase for Danfoss, and we became a very special role model. At the same time, there were many development projects with the T2, with copper capillaries and brass sensors. We kept looking all the time to see if things could be produced better and more effectively," Jens Jensen explained, who was then employed as a machine maintenance worker.

Christian Mortensen, previous project manager for the T2, agrees:

"There was a great atmosphere at L3. You could feel that we were close to the core, and we got a lot of attention from the Clausen family. L3 is where it all started. The entire organization knew the importance of what we were doing. Jørgen Mads Clausen would very often drop by. He had gone to school with the operations manager, and they would often stop and chat. When Jørgen Mads Clausen would come, all the employees were on their toes. This gave us extra energy. In many ways, we played a part in establishing indicators for how production can be set up, not just at Danfoss, but also for other companies. We had something to contribute, and this resulted in numerous visits from outside L3."

Automatik Divisionen, AG-R

Ventiler à la carte

Et af verdens mest avancerede produktionsanlæg har til huse hos Automatik Divisionens forretningsenhed for Køle- og A/C-automatik. Den computerstyrede teknik gør produktionen langt mere fleksibel og medarbejdernes hverdag mere afvekslende.

Af Tina Hardervig

NORDBORG: Kunderne får opfyldt deres krav om fleksibilitet og fejlfri produkter.

Medarbejderne har fået ændret deres arbejdsopgaver og fået en mere afvekslende dagligdag. Danfoss er blevet mindre afhængig af udsvingene på markederne og i lagerbeholdningerne. Det er nogle af fordelene ved det fuldautomatiske og computerstyrede produktionsanlæg, der producerer ventiler hos Automatik Divisionens forretningsenhed for Køle- og A/C-automatik, AG-R.

– Vi kan producere T2-ventilen og den nye TU-ventil af rustfrit stål i forskellige varianter i vilkårlig rækkefølge, fortæller Flemming Hald, mens han forklarer om dyse-, fiksér, element- og montagelinjerne.

– Hver ventil er fulgt af en databærer, der er programmeret på forhånd, så den styrer operationsgangen på montagelinjen.

– Hver enkelt deloperation bliver kontrolleret, umiddelbart efter at den er udført, så vi har 100 procent kontrol på hver ventil. Er der en fejl, bliver ventilen sendt direkte tilbage til operatøren, der vurderer og retter fejlen. – Vi kontrollerer også anlægget dagen igennem ved at sende gode og dårlige »dummy'er« gennem linjen for at se, om systemet giver de rigtige fejlmeldinger.

– Derudover bliver alle data fra produktionen gemt, så vi har en kvalitetsrapport på hver enkelt ventil. Det sætter især vores store OEM-kunder pris på, siger Flemming Hald.

Selvstændigt arbejde

Ordrerne på TU- og T2-ventiler bliver tastet direkte ind i edb-systemet. Her kan operatørerne blandt andet aflæse de enkelte ordrer og lagerbeholdninger og derudfra selv beslutte, hvilken produktion de vil sætte i gang.

Lone Pustelnik ved montagelinjen, der ved hjælp af en databærer ved de enkelte ventiler kan producere TU- og T2-ventiler vilkårligt mellem hinanden.

– Man skal være vågen og bruge både sit hoved og sin erfaring, siger Lone Pustelnik, der er glad for sit arbejde ved den 35 meter lange montagelinje, hvor hun har arbejdet i godt et år.

Som sine kollegaer skifter Lone Pustelnik arbejdsområde ved montagelinjen hver tredje dag. Hun skal blandt andet reparere ventiler, programmere, passe linjen og klare administrative opgaver.

– Det kræver efteruddannelse, og man skal ikke være bange for at røre ved knapperne på maskinerne. Til gengæld får man et stort overblik, når man kender alle processer, og så bliver det nemmere at rette fejlene, siger Lone Pustelnik, der ind imellem også arbejder ved de ældre fuldautomatiske linjer.

Nye tanker og krav

Flemming Hald, Lars Otten og Ejnar Poulsen er alle med i den projektgruppe, der arbejder med det produktgenerations- og teknologiskifte, som det nye produktionsanlæg også betyder.

– Baggrunden for projektet var, at vi ønskede at tilfredsstille de øgede miljøkrav, at have en fleksibel og kundetilpasset produktion, at formindske vores gennemløbstider og forbedre kvaliteten ved hjælp af 100 procent kontrol af produktionen, siger Lars Otten.

– Vi ville gerne ændre produktionen til at være ordrebaseret med en minimum ordrestørrelse på ét stk. for at formindske vores lagre.

– Med det fuldautomatiske og computerstyrede produktionsanlæg kan vi hele tiden justere produktionslinjen, og det gør os mere uafhængige af markedet.

– Anlægget holder selv styr på varianterne, og ordreantallet er ligegyldigt. Rent teoretisk er der to millioner varianter af TU-ventilen!

Men det er ikke kun kunderne, der bliver berørt af den nye produktionsform:

– Det er en stor udfordring for operatører og vedligeholdere, arbejdsledere, ingeniører og teknikere, siger produktionschef Palle Kruse.

– De skal nu arbejde i grupper, hvor de får andre arbejdsopgaver og skal gøre sig nye tanker og overvejelser.

– Hele organisationen bliver involveret og skal gå i spænd for, at det skal kunne fungere – men det er sundt at blive udfordret på den måde.

– Markedsmæssigt har det nye produktionsanlæg ikke givet problemer eller reklamationer. Det har vi heldigvis været forskånet for – vi har kun fået positive tilbagemeldinger fra kunderne.

Production employee Lone Pustelnik in 1994. She still works with the T2 and has done so for 38 years. Article from the Danfoss Article from the internal magazine, Danfoss Avisen.

Bitten Clausen, Mads Clausen's widow, would often drop by L3, and a few years later, when she appointed production employee Chrestine Hermansen as Danfoss Ambassador, an employee who has made an extra effort for Danfoss, she said, "Take care of L3, it has always been close to Mads' heart."

L3 is where it all started. The great industrial fairy tale. And if you really try, perhaps you can still sense the special Danfoss spirit from back then.

1990

> *I clearly remember the feeling when my first valve rolled out with a nice little flag in it.*

L3 – a Good Place for Women

In 1990, Christine Hermansen, known as Stinne, started as a production employee. By the time she left production, two million T2 valves had passed through her hands. Today she is a tour guide and recounts with zest and zeal about her fantastic years as a production employee to politicians, customers, students, associations, presidents, queens, and all others interested in Danfoss.

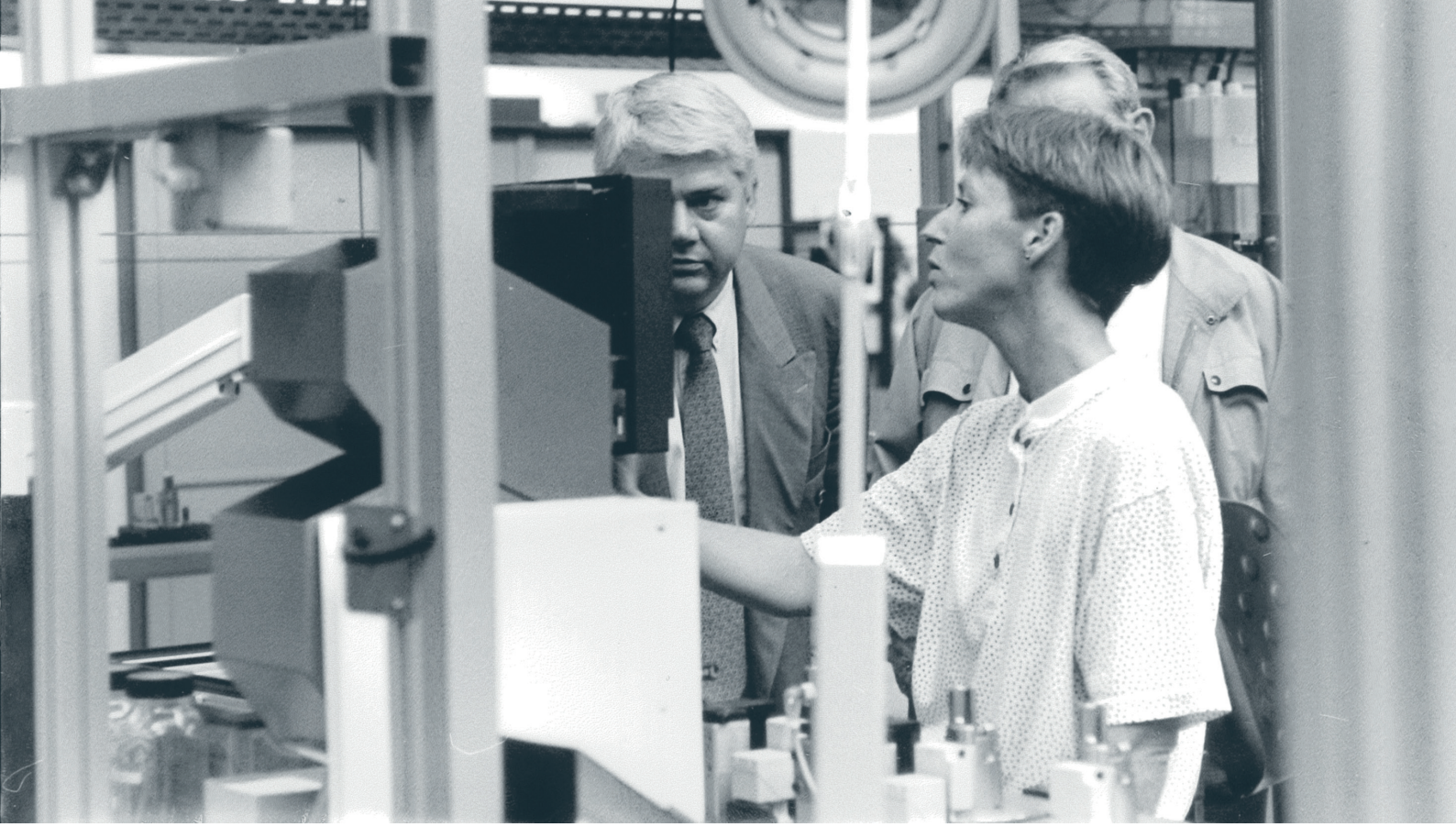
Stinne worked in production for 12 years:

"Back then it was a real women's workplace. There are still many women in production today, but at that time there were even more. We had only manual job positions. All the automation would come later. It was a really good place for women. I worked for four years on the weekend shift. It was 12.5 hours twice each weekend."

On a typical shift there were between 40 and 60 production workers on the job, and in addition there were installers and machine maintenance workers.

"Every time we ran a new customer order with a new setting, the installers would begin to configure the machines for the work we had to do. And we had many so-called machine maintenance workers, who repaired the machines and made sure that everything ran as it should. Each process was a combination of manual labor and machines. We had, for example, a large wrapping machine, which we called ELGA."

Stinne clearly remembers when she made her first T2 valve: "We stuck in a Danish flag whenever a new production employee had been to all stations and had given birth to the little newborn valve. I clearly remember the feeling when my first valve rolled out with a nice little flag in it.



Stinne Hermansen and Jørgen Mads Clausen.

It was fantastic. I was very proud. The T2 is a special product for me, and I have given them a nickname. They are my *gold nuggets*."

"There is a lot of handicraft in a T2 valve. You have to have good manual dexterity, and many women have this. One of the ways we could see whether a production employee was accomplished or not was whether the gloves we used to roll capillary tubes would quickly wear out. If a fellow employee was good at rolling, you could hardly see that the gloves had been used. It was also quite evident whether they were left- or right-handed. This could be clearly seen in the way the glove was worn out. We always talked about right or left gloves – even when we were talking about each other," Stinne laughed.

1992

Henrik Denning at the podium for the opening of the new production line for the T2.

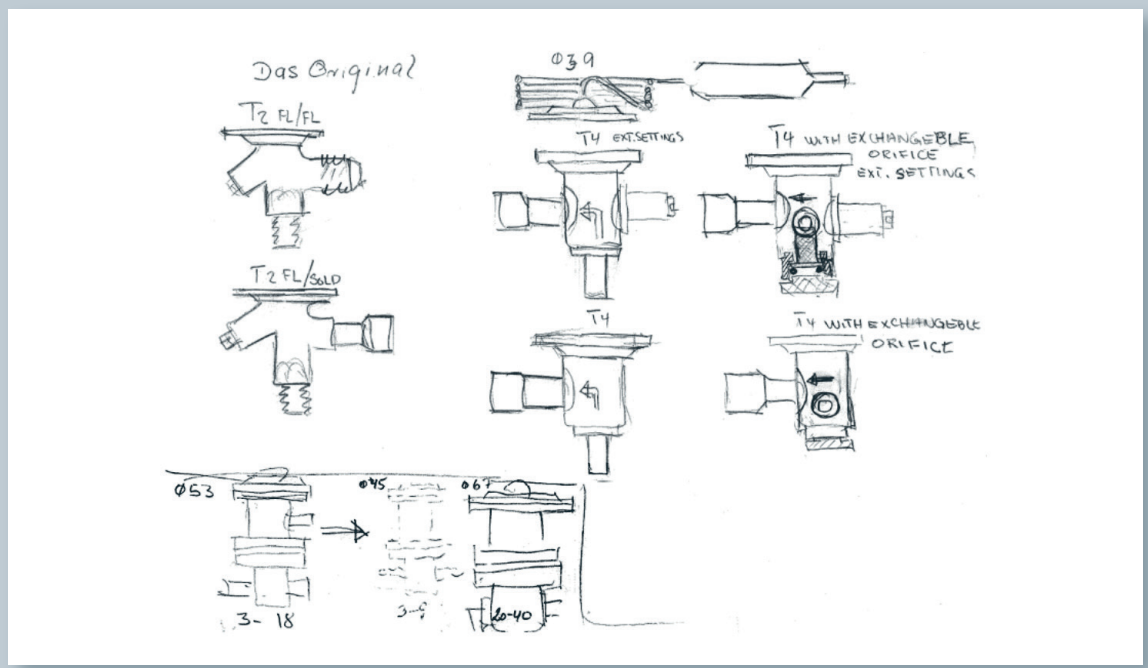
Iron Henry and the Tireless Forces

Henrik Denning joined Danfoss from Nørrebro in Copenhagen. Like many others at Danfoss, he had a background as a maritime chief engineer from Copenhagen Mechanical School, and even though he has not quite shed his Copenhagen dialect and is in his mid-eighties, he is still passionate about the story of the T2. So much so that his eyes sparkle and his tone of voice intensifies. Here is a man who really fought for the T2 valve.

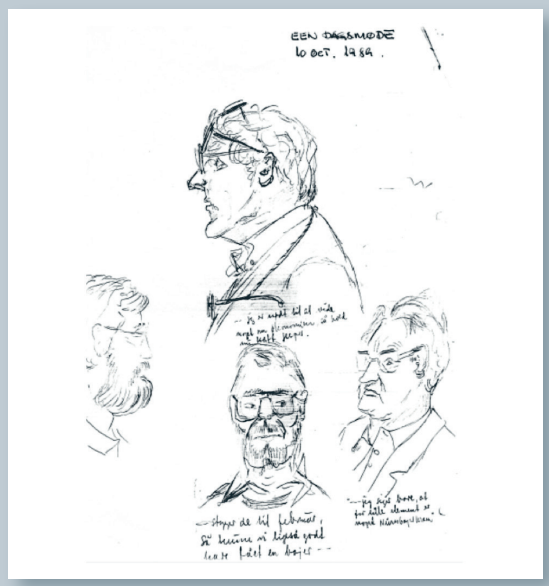
In the 1970s, Henrik Denning wanted to replace the stainless membrane capsules with iron, and therefore he was nicknamed *Iron Henry*, the traditional Danish translation for *Dennis the Menace*.

"Iron Henry" started at Danfoss as a production supervisor in 1955 and was later appointed Section Manager at L3 in Nordborg, where he was responsible for product and process development of thermal valves. A formidable task awaited him: Re-launching the thermal valve program.

"Working on the T2 valve is part of my life's work and a job that I'm proud of. It became a hobby that I even got paid for. We were a small group of enthusiasts, a real *dream team*, and our mission was to create a greener and more environmentally friendly manufacturing concept. Thus we set out to rethink the T2. As project manager and section manager for the T2, I established Project Thermal Valve, led by a steering committee with Jens Gammelby at the helm. A group of managers and employees from different areas of the organization were also part of the group. ▶



Henrik Denning's first sketch for a new and improved valve program, designed on the back of a menu at a restaurant in Offenbach, Germany. The design is dated November 21, 1991.



Henrik Denning, Hans Jørgen Jespersen, Jens Hansen and Anders Vestergaard. One-day Meeting of Project Thermal Valve in 1989. Design by "Skawbo" (Jørgen Jensen)

Henrik Denning at a project meeting of Project Thermal Valve. Design by Jørgen Jensen aka "Skawbo".

Golden Egg with an ordinary hen's egg. Advertising from the 1990s.

► Finn Fastrup later took the helm from Jens Gammelby. The interesting aspect of the project group constellation was that it was extremely interdisciplinary. In addition to the project group, we involved employees from different areas of the organization as well as external partners in Project Thermal Valve. Moreover, I also involved a retired employee to ensure we retained important history," says Henrik Denning.

The project was established in 1990 and existed until the mid-1990s. The project was initiated by the Marketing Department since there was a demand for a cheap soldered valve on a market that was moving away from screw joints due to environmental requirements.

In the beginning things went slightly uphill for Project Thermal Valve, in that the initial market feedback was: *Do not touch the T2 – our golden egg*. But the team managed to convince management of the need to re-design the T2, and in 1992, Project Thermal Valve received 40 million Danish kroner for a new production concept. It was the largest budget ever granted for the development of a product and a production. Back then.

As the driving force in Project Thermal Valve, Henrik Denning used his iron will, and through collaboration across functions and with good outside partners such as Poul Johansen Machines, which provided support with new machines for the production of the thermal valves, he and his project team managed to ensure the future of T2 production.

"We were supposed to create a concept where all manufacturing processes were to be green, as far as possible. Furthermore, the production of the thermal valves had to be automated. With all these improvements, we managed to produce a brand new valve: the TU-valve for the U.S. market."

Iron Henry and the steel man. Henrik Denning (left) is presented with an award for excellent customer conduct from the head of the department for chipless machining, Egon Hansen. The figure is a handmade steel man made from parts of valves.

The TU consists of simple parts made of stainless steel using non-cutting processes produced with robots.

”Unfortunately, our estimates showed that the number of units would incur an unacceptable pay back. We therefore redesigned the T2 valve so that it could be integrated with the TU program. It succeeded beyond all expectations. If we had not made the adaptation of the T2 valve, including by using the technology behind the TU, it is doubtful that the production of thermal valves would exist in Nordborg today. That Project Thermal Valve was completed successfully, largely due to the enthusiasm and engineering clout that the *The Dream Team* possessed.”

1993

Torben Matzon in 1982.

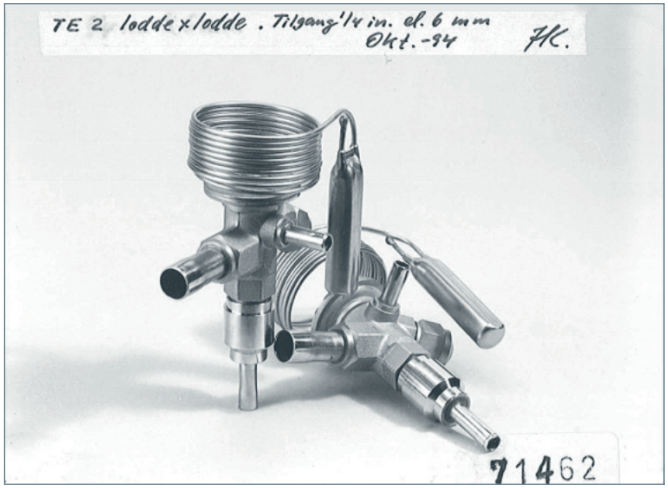
The Wooden Leg

Jens Jensen and Christine Hermansen are one of the many married couples in Southern Jutland where both spouses work at Danfoss. Jens Jensen started in 1979 as a machine maintenance worker, and just like his wife, he also has extensive knowledge of the T2, and they have both been part of this great T2 industrial fairy tale.

Today everyone at Danfoss has English titles, and Jens Jensen is employed as Process Technology Project Manager.

Jens explains, "In 1992-93, together with production supervisors Torben Matzon and Henrik Denning, I went through a process where we had to choose suppliers. There was a mix of Danish and German suppliers. They had developed a rating system with 10-20 different weighting options and scoring for the machine maintenance group and the product technology people. Those were special machines that we developed ourselves. For example, we had a deburring process in which the holes were deburred in the T2 valve. The operators did it manually. At one point we developed a highly advanced machine for the process."

Torben Matzon has worked for over 30 years in the large factory hall L3 in Nordborg, including as an engineering intern, safety manager, and as head of factory support. Just like Jens, he



The T2 solder, called the Wooden Leg.

started in 1979. The success behind the T2, according to Torben, was that the installer could come out with a service case, and he had everything he needed at hand.

"The T2 was easy to install, it had a long life, and so the service concept was a hit. The T2 could cover for many valves, and where the installer previously had to use six different valves, he could settle on one, and it was the T2."

Throughout time the T2 has repeatedly been threatened with extinction. Torben related,

"In 1994, the trend was towards soldered valves. The T2 valve had a screw joint. There were laws in Sweden and Germany against screw joints, and they do not constitute hermetic closures. In Sweden they therefore opted to go the other way, by requiring additional inspection. The T2 was threatened in its very existence. We therefore created an intermediate solution called the *T2 Solder*. We referred to it as *the Wooden Leg*. The nozzle on the new T2 could not be changed. In this way we were able to keep the pot boiling. But many predicted that the T2 would become extinct. It did not, because we constantly considered this and replaced parts and fillings in accordance with legislation."

1994

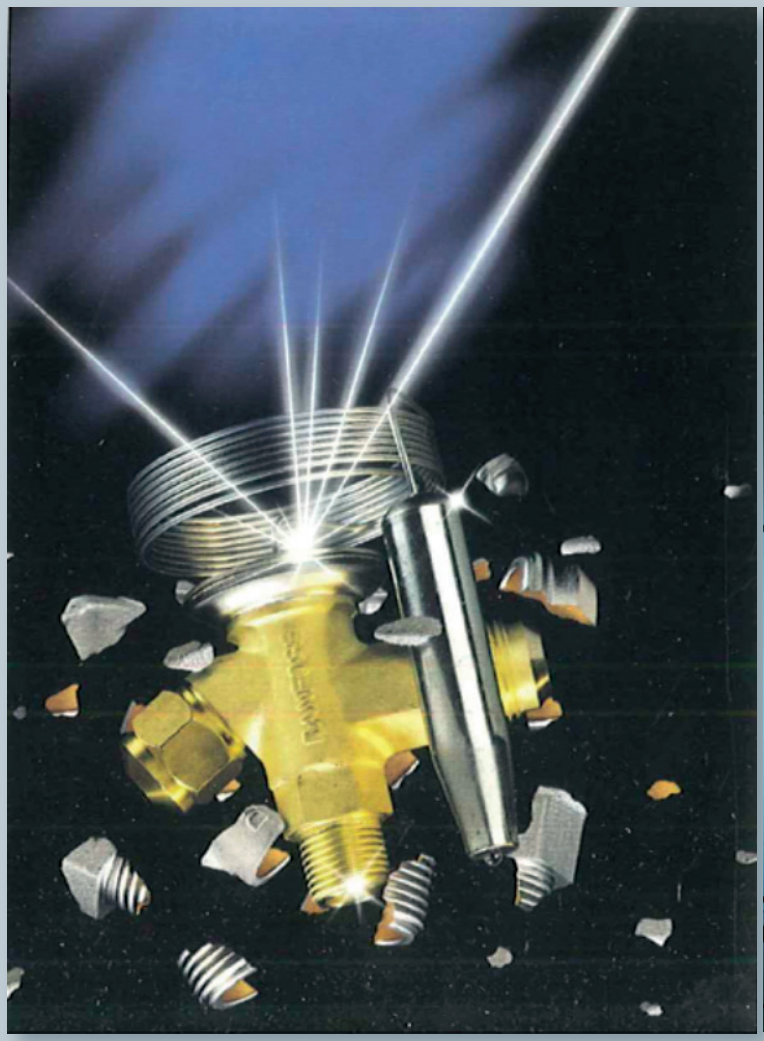
From Nickel Plate to Brass and Laser Welding

In 1994, Danfoss eliminated nickel plating on the valve, and it was marketed with a large advertising campaign, in which the T2 burst out of its shell and proclaimed that the valve was now nickel-free.

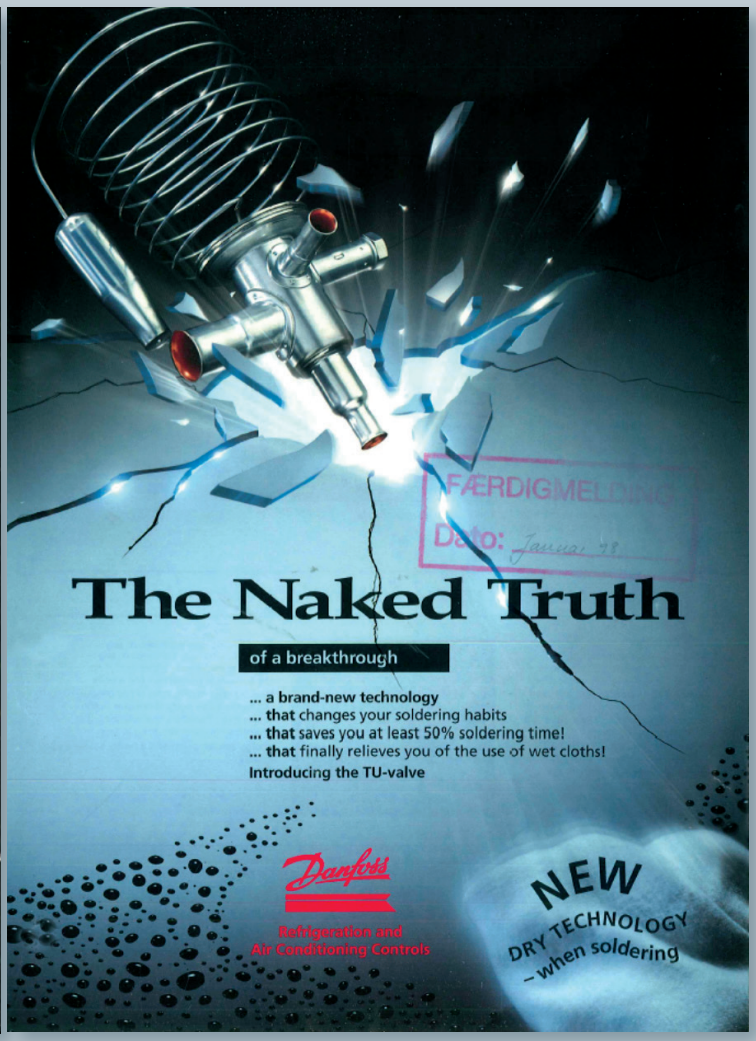
Christian Mortensen started at Danfoss as an engineering intern in 1990. Following his internship, he came to factory hall L3 in 1992 under the management of Torben Matzon and Henrik Denning, who ran the production side. Christian was the first PT employee. PT is an abbreviation for Product Technology, and he later had project responsibility for capacity expansion of the T2 production.

"When I started, T2 production was relatively manual. There were a lot of employees and much of the equipment was semiautomatic. I first worked with laser welding. Laser welding and laser engraving were my primary responsibilities," said Christian Mortensen.

"When we invested in new production equipment, it was important for it to be forward looking. At the time our volume was at one million T2 valves per year, but we had to expand to two million, and this required investment in new equipment. The advantage of the T2 was that we had a very high sales volume and the market and the customers were already there. I am proud that I helped to invest in the right equipment from the very start. We made some important decisions at that time, and that is the reason why production still takes place today at L3. The management was very forward looking, and we established a production line that could be expanded as needed with regard to product variants and capacity. ▶



In 1994, there was a design improvement in the T2. The T2 lost its nickel coating and was marketed as less harmful to the environment.



Advertising from 1998 for the TU valve that targeted the North American market.

Operator Karin Hansen on the Rocket Chair at the pressure testing plant (left).

The futuristic rocket chair was an attraction for everyone who visited L3 in Nordborg (right).

► Although I did not have direct customer contact, I knew that the customers were relatively conservative. The marketers succeeded in convincing the customers that the new valve with a stainless sensor was just as good as the old one," Christian said.

Finn Fastrup, a marketing employee who later became divisional president, used an approach that worked on the sales figures:

"We went out to the customers and showed what happened when we bent the old nickel-plated valve, because it broke. We could bend and stretch the new model without it breaking, and then the customers were convinced that the new valve was even better than the old one."

Goodbye to the Rocket Chair and Welcome to Langelinie

Schoolchildren on class trips loved it. Everyone wanted to try it. *The Rocket Chair*. Even the big government leaders, cabinet ministers, and politicians got a turn. The chair was really just an ordinary office chair, but it was mounted on long rails, so that the assembly employee could quickly get from one end of the production plant to the other. The chair was designed in 1970 and survived until 1994, when the big factory hall L3 underwent a radical change.

Stinne Hermansen was one of the production employees who at times had her permanent workplace on the *Rocket Chair*, and she found it effective, but certainly not comfortable.

"We called it both the *PR Chair* and the *Rocket Chair*. There was something a bit science fiction and Star Wars about it, and the newspapers always wanted to photograph it. At one time it broke and we decided not to fix it. It was not very good on your back. Certainly not comfortable, but we could move incredibly fast and in this way was it effective. But frankly, I

Photo from the opening of the new production plant for the T2 in 1994. Vagn Helberg at the rostrum. Standing: Jørgen Mads Clausen, Henrik Denning, Finn Fastrup, and colleagues involved with the T2.

was a bit glad when it was discarded and ended up at the recycling center, as it was certainly not ergonomically correct."

Langelinie

In 1994, Danfoss invested in a new production plant at L3, and because of its length, the plant was quickly renamed *LANGELINIE* – the long production line – almost as long as the long quay in Østerbro in Copenhagen.

On September 1, 1994, the first phase of the fully automatic production line for T2 expansion valves was put into operation.

The former President of the Refrigeration and Air Conditioning Division at Danfoss, Finn Fastrup, pressed the start button.

In 1995, the plant was also ready for the TU valves, right on schedule. However, since then, TI and T2 sales have risen so much that a new line was built for the TU, to make more room for the T2 at *Langelinie*.

The production plant at L3 in Nordborg on Als has over time become one of the most visited at Danfoss – and when there is a television camera at Danfoss in Nordborg, it is often *Langelinie* that appears on TV screens in the living rooms.

Former Divisional President Finn Fastrup about to press the button that opened Denmark's first and most ultra-modern production plant. At that time, it was the largest investment in Danfoss' history, but the plant is still working and has recouped the investment many times over.

The red button.

In 2014, Danfoss celebrated the 20th anniversary of Langelinie, and Finn Fastrup was informed by an employee that he had not started the production by pushing a red button; it had actually been someone else. The red button was not in fact real - it was set up for the occasion. The man who pressed the real button was Flemming Hald and he is still employed at Danfoss as an engineer.

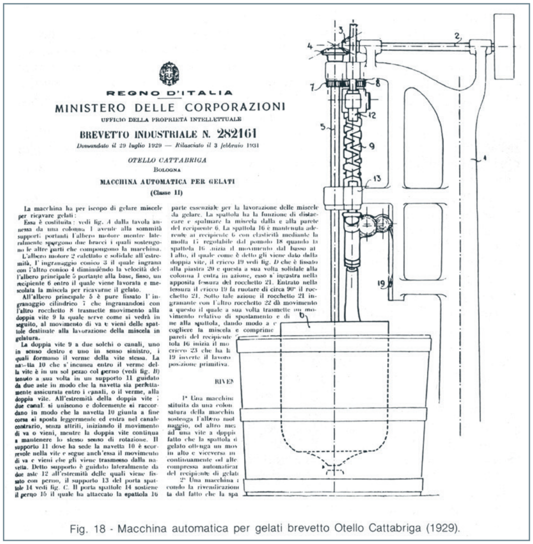
1996

Italian Ice Cream with Homemade Wrench

Carpigiani is an old and cherished customer who has worked together with Danfoss longer than anyone can remember, and for years Danfoss' products have contributed to the refrigeration of tasty Italian ice cream. Carpigiani started making ice cream machines in 1946 and quickly established the company as a market-leading ice cream machine manufacturer, specializing in gourmet ice cream – the Italian gelato. In the 1960s and 1970s, the Italian ice cream culture spread all over the world, and Carpigiani opened the first overseas department and expanded with a large sales network. Today, Carpigiani has more than 500 service centers worldwide, and also operates a museum as well as a university – Carpigiani Gelato University, the world's only university where students from around the world can learn more about the art of the famous Italian gelato.

In 1996, the first encounter with the new T2 refrigeration valve resulted in the locking of horns. Carpigiani complained that Danfoss had not set up the valves properly. They used the phrase "as the wind blows," and product expert Svend Stuhr Jepsen from Danfoss was sent to Italy to rectify the matter. Along with the local Danfoss Account Executive in Italy, Massimo Alotto, Svend visited the ice cream machine manufacturer, who to this day is still a good, loyal Danfoss customer.

According to Svend Stuhr Jepsen, the meeting between Svend, Massimo and Carpigiani lasted five minutes in English, and then continued at a slightly louder tone of voice in Italian. The Danfoss delegation alleged that Carpigiani changed the setting by turning the nozzle too far with the valve, but the customer would not accept this, and they parted without having solved the problem.



REGNO D'ITALIA

MINISTERO DELLE CORPORAZIONI

UFFICIO DELLA PROPRIETÀ INTELLETTUALE

BREVETTO INDUSTRIALE N. 282161

Domandato il 29 luglio 1929 — Rilasciato il 3 febbraio 1931

OTELLO CATTABRIGA

BOLOGNA

MACCHINA AUTOMATICA PER GELATI

(Classe 11)

La macchina ha per iscopo di gelare miscele per ricavare gelati:

Essa è costituita: vedi fig. A dalla tavola annessa da una colonna 1 avente alla sommità supporti portanti l'albero motore mentre lateralmente sporgono due bracci i quali sostengono le altre parti che compongono la macchina.

L'albero motore 2 calettato e solidale all'estremità, l' ingranaggio conico 3 il quale ingrana con l'altro conico 4 diminuendo la velocità dell'albero principale 5 portante alla base, fisso, un recipiente 6 entro il quale viene lavorata e mescolata la miscela per ricavarne il gelato.

All'albero principale 5 è pure fissato l' ingranaggio cilindrico 7 che ingranandosi con l'altro rocchetto 8 trasmette movimento alla doppia vite 9 la quale serve come si vedrà in seguito, al movimento di va e vieni delle spattole destinate alla lavorazione della miscela in gelatura.

La doppia vite 9 a due solchi o canali, uno in senso destro e uno in senso sinistro, i quali formano il verme della vite stessa. La navetta 10 che s' incunea entro il verme della vite è in un sol pezzo col perno (vedi fig. B) tenuto a sua volta in un supporto 11 guidato da due aste in modo che la navetta sia perfettamente assicurata entro i canali, o il verme, alla doppia vite. All'estremità della doppia vite i due canali si uniscono e dolcemente si raccordano in modo che la navetta 10 giunta a fine corsa si sposta leggermente ed entra nel canale contrario, senza attriti, iniziando il movimento di va o vieni, mentre la doppia vite continua a mantenere lo stesso senso di rotazione. Il supporto 11 dove ha sede la navetta 10 è scorrevole nella vite e segue anch'essa il movimento di va e vieni che gli viene trasmesso dalla navetta. Detto supporto è guidato lateralmente da due aste 12 all'estremità delle quali viene fissato con perno, il supporto 13 del porta spattole 14 vedi fig. C. Il porta spattole 14 sostiene il perno 15 il quale ha attaccato la spattola 16 parte essenziale per la lavorazione delle miscele da gelare. La spattola ha la funzione di distaccare e spalmare la miscela dalla e alla parete del recipiente 6. La spattola 16 è mantenuta aderente al recipiente 6 con elasticità mediante la molla 17 regolabile dal pomolo 18 quando la spattola 16 inizia il movimento dal basso al l'alto, il quale come è detto gli viene dato dalla doppia vite, il cricco 19 vedi fig. D che è fissato alla piastra 20 e questa a sua volta solidale alla colonna 1 entra in azione, esso s' incastra nella apposita fessura del rocchetto 21. Entrato nella fessura il cricco 19 fa ruotare di circa 90° il rocchetto 21. Sotto tale azione il rocchetto 21 ingranante con l'altro rocchetto 22 dà movimento a questo il quale a sua volta trasmette un movimento relativo di spostamento e di
ne alla spattola, dando modo a
cogliere la miscela e comprime
pareti del recipiente
tola 16 inizia il mo
cricco 23 che ha la
19 inverte il lavoro
posizione primitiva.

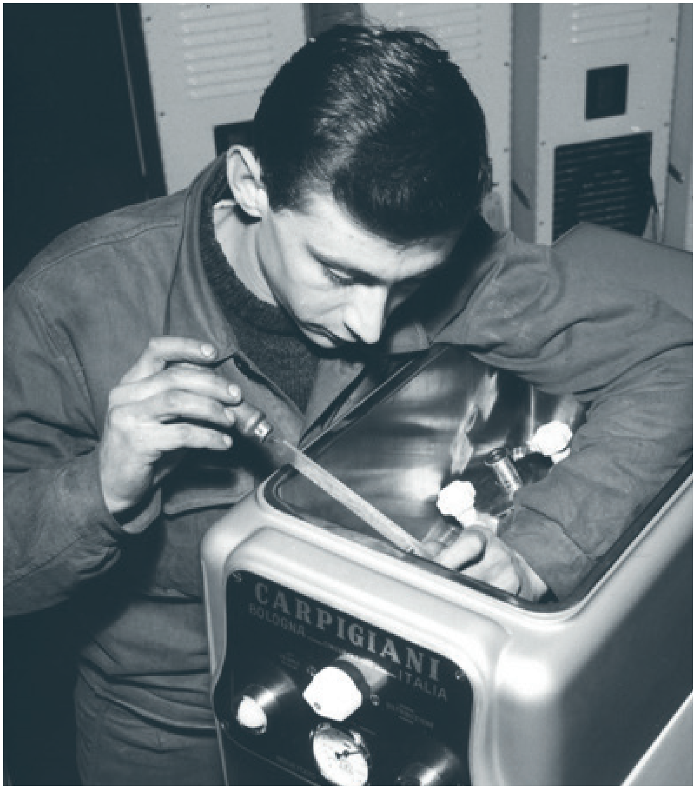
RIVEN

1° Una macchina
stituita da una colon
satura della macchin
sostenga l'albero mot
naggio, od altro me
ad una vite a doppi
fatto che la spattola
gelato ottenga un mov
in alto e viceversa
continuamente od alte
compressa automatica
del recipiente di gelat

2° Una macchina
condo la rivendicazion
ta dal fatto che la spa

Fig. 18 - Macchina automatica per gelati brevetto Otello Cattabriga (1929).

Drawing of a fully automatic ice cream machine for the production of Italian ice cream - gelato - from 1929. Courtesy of Carpigiani.



"My boss was sent down and concluded the same thing that Massimo and I did. He went out to the production at the ice cream factory and saw that the T2 was tightened too much. The customer wanted to have it be tight, so they had lengthened their wrench with a pipe so that it had become huge. The homemade wrench was simply too powerful for the little valve, which had been completely deformed by the pressure of the giant wrench. Massimo and I have visited Carpigiani several times since, and we have never seen the gigantic wrench," smiled Svend. ▶


DAIRY PRODUCTS FOR
CARPIGIANI


BOLOGNA
ITALIA
CARPIGIANI
10
Zanetti
ARCHIVIO GELATO MUSEUM

I look forward to continuing the journey that Danfoss and Carpigiani began together.

Roberto Lazzarini

► T2 at a Museum in Italy

Roberto Lazzarini is the head of Research and Development, responsible for engineering and after sales services at Carpigiani. He has worked for Carpigiani for 20 years, but no longer remembers the episode with the wrench:

"As market leader and world's largest ice cream and gelato machine manufacturer, well-functioning refrigeration systems are extremely important to us. Danfoss has been our preferred supplier since the company's inception. Cooperating with Danfoss is incredibly important to us. Danfoss is not just a supplier, but a technical expert. They do much more for us than just selling applications or components. It is a very valuable partnership. We only use thermostatic expansion and solenoid valves from Danfoss - simply because they are the best, and with them comes the best know-how. As a leading ice cream machine manufacturer, we require the best refrigeration systems. The Carpigiani's motto, *Technology for a Sweeter World*, is reflected in our strong commitment to engineer and develop innovative equipment that maintains the highest standards of quality. 100,000,000 people a day eat an ice cream, or consume a drink, from the 500,000 Carpigiani machines installed worldwide."

According to Roberto Lazzarini, innovation is extremely important for Carpigiani:

"Our ice cream machines must be able to heat and cool, and they must be able to change the temperature quickly. These features require special technology and design of the ice cream machines' refrigeration systems. We redesign our ice cream machines every year because of changes in regulations and technical standards. Our machines require specialized and sound technical knowledge."

The year 2016: A soft ice cream at the perfect temperature for a hot summer, thanks to the ice cream machine from Carpigiani and valves and application know-how from Danfoss.

In 2012, Carpigiani opened an ice cream museum, Museo Gelato in Bologna in Italy, where many Danfoss products including the T2 are exhibited. Visit the museum at http://gelatomuseum.com.

In order to make good ice cream, it is important to have a strong partnership with a supplier:

"The supplier must be able to understand our special requirements. Danfoss is that kind of partner. Our expansion valves are made especially for us by Danfoss. They cannot be bought on the market. Our designs often change, and we need a supplier like Danfoss to ensure that we can deliver to a dynamic market. We launch new products every year, and every year there is a new development task. Danfoss is not just a supplier of components or a sales company – they know Carpigiani and our refrigeration systems incredibly well. To us, Danfoss is an accomplished and important partner. Danfoss is always close to us. It is extremely important for our development that we are always able to get local support from Danfoss. I look forward to continuing the journey that Danfoss and Carpigiani began together many years ago."

2008

> *We opened in China on August 8, 2008, at 8 o'clock.*

The T2 finds its Second Home in China

The eighth day of the eighth month, two thousand eight, at eight o'clock. The number 8 is a lucky number in China, and there were plenty of eights when Danfoss opened the new T2 hall in Wuqing, China. But before the silk ribbon was cut and the new factory was ready to parallel produce the T2 in China, a hectic year and a half had passed.

Tommy Due Jensen was project manager for the setup of the T2 product line in China, and with nearly 36 years of experience at Danfoss, he recalls the opening day as something very special and meaningful.

"We opened in China on August 8, 2008, at 8 o'clock, at the same time as the Summer Olympics in Beijing. It was a very festive day, and we breathed a sigh of relief because we pulled it off right on time. I am very proud that we actually managed to deliver the new production line for two million Danish Kroner less than I had budgeted. Everybody worked extremely long, hard hours for one and a half years. For long periods I saw more of my colleague, Chang Lianhe, and my other Chinese colleagues than I saw my wife, but without offending her, it was all well worth the effort. I lived for a year in Beijing, but all the preparations began in Denmark, where we invited future Chinese employees for training. Here we also visited the Hans Christian Andersen house in Odense and took part in some social events in order to get to know each other better. It made the job much easier, because we already knew each other when we met again in China to increase T2 production." ▶

Tommy Due Jensen and Chang Lianhe at the opening of a parallel production in China in 2008.

The new factory in Wuqing during construction of the factory for the T2 in China in 2008.

In China, they began installing equipment and conducting training before the walls were put up. When a chair was missing, they found a water container. Everybody working with a clear goal: They were to open simultaneously with the Summer Olympics in Beijing.

The new Chinese employees visited Hans Christian Andersen's house in Odense, in order to learn more about Danish culture.

► The new production plant for the T2 is an extension of the existing factory in Wuqing. At the beginning, there was only the 2400 square meter hall, completely empty, and the team worked in the large open room before all the walls were put up. Tommy explains:

"There were no doors and only a few windows and it was very hot. To begin with, we only had power for construction and no air conditioning. We quickly installed a few freezers for cold water, and then everything went fine. Everyone pitched in and there was a really good team spirit. We just wanted to be ready for August 8. I often think about the nice lady who swept up the construction dust in the large open hall every day. She started early in the morning, and when she went home at night, she had swept the entire length of the hall; the next day she started all over again. Meanwhile we installed equipment, but there were no complaints even though it was often over 40 degrees Celcius in the factory hall. "

The Eternally Young T2

Chang Liang joined Danfoss in 1999 as a process engineer, and he received Employee No. 180.

"There is a number eight in my employee number, and eight means "rich" in Chinese, which is why it is the most popular number."

Today he is a machine maintenance manager and clearly remembers setting up the parallel production for the T2 at the factory in Wuqing.

"I spent a lot of time with Tommy Due and the team, and I must admit that when we reached the August 8 countdown date, I was very happy. Even though we celebrated the opening of Danfoss on the same day as the Summer Olympics, I arrived back in Beijing where there was yet another party. That was a fantastic time with many positive experiences."

According to Chang, the T2 is a stable valve and the best product in Danfoss' portfolio.

"It is currently the best valve on the Chinese market. In terms of quality, it is the king of hill. We

Chang Lianhe with the T2 in 2015.

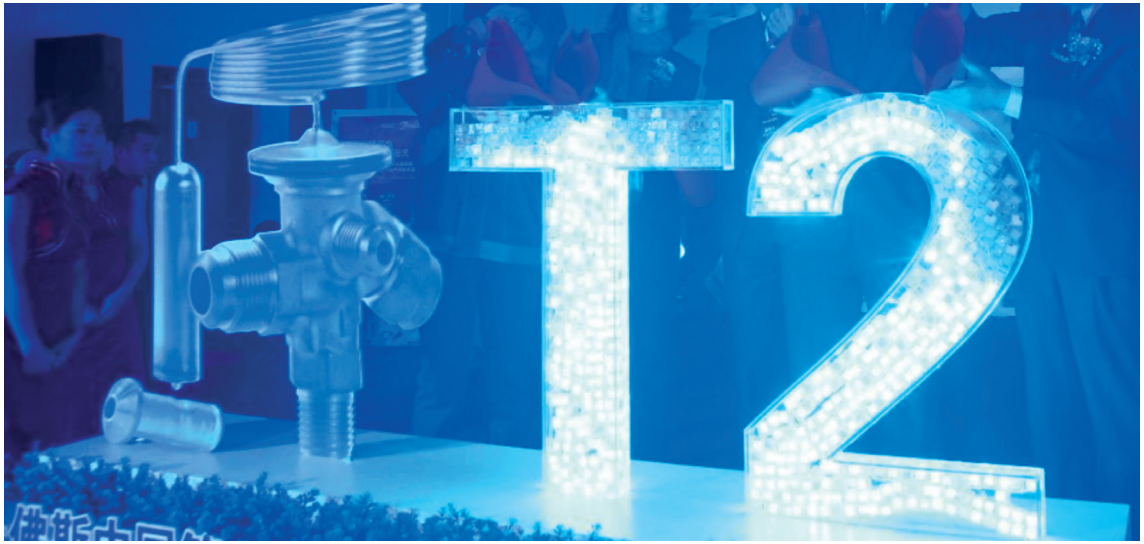
have never had any problems with it. Even though this is its 50th anniversary, it is still young and fresh. It will be in production for another 25 years."

With a smile on his lips at the prospect of the T2's 75th anniversary, Chang recounts why he has been at Danfoss for so long.

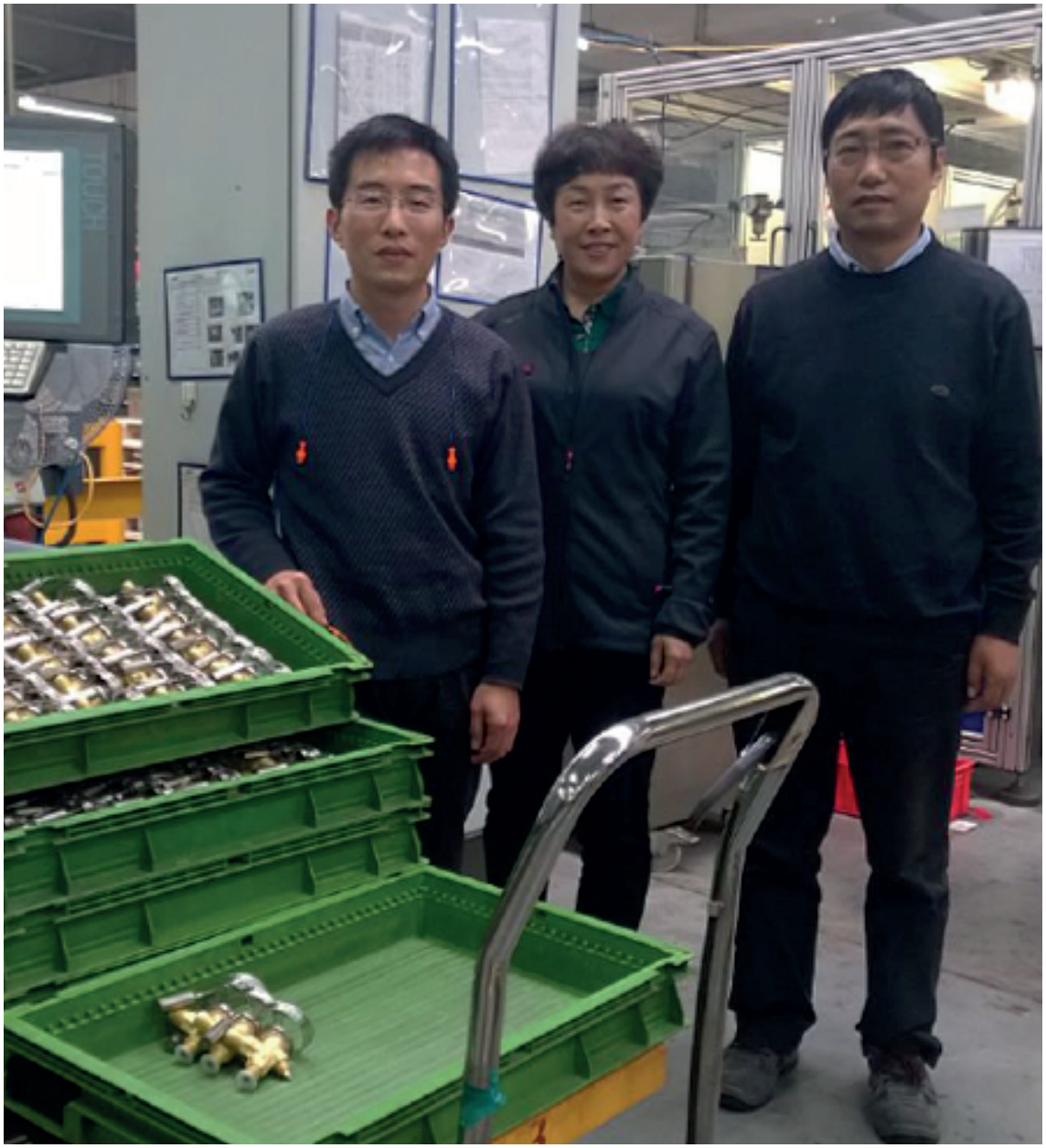
"Danfoss is a Danish, family-owned company, and I like the Danish working culture. Everyone is equal. There is no hierarchy. Whether you are a production employee or a manager, we listen to each other and discuss things until we achieve the best result. In many large Chinese firms, you never see a boss, and if you do, then he certainly does not greet you. I have never experienced this at Danfoss."

The T2 has been compared to *The Nightingale*, from Hans Christian Andersen's fairy tales, because even if it is produced identical to the T2 in Denmark, it still has a small piece of Danish mechanics inside - the membrane is actually still made at the Bellows Factory in Nordborg.

In December 2014, Danfoss in China celebrated that three million T2 valves had rolled out from the assembly line and ensured stable and energy-efficient refrigeration and air conditioning for the Asian market.



The production of three million T2 valves was celebrated by 200 guests in December 2014, at the Danfoss factory in China. The T2 was hailed with a luminous sculpture that changed color as it froze to ice.



Production in China.

Production of T2 valves in L3, Nordborg.

2015

During his 35-year career, Technical Manager H. Jessen Jürgensen – Beijer Ref, has shipped hundreds of thousands of T2 valves for customers in the Nordic countries.

The Hairpin and the Water Tap

There is no doubt that all of Danfoss is pleased with and proud of the little T2. But the enthusiasm for the golden egg also extends to the customers.

Even though the T2 has undergone many changes during the last 50 years, wholesale distributors and customers have not noticed any difference. The T2 has new fillings, has been prepared for new refrigerants, and has passed through the hands of countless employees before arriving to the customer. But on the customer side, they have not noticed any major change. The T2 is and will always remain a gallant valve.

For many years, sales managers at Danfoss asked their wholesale distributors about their satisfaction, and they always got the same answer: "It works perfectly. It's a really good and nice little valve."

Jan Lund, the technical manager in the wholesale company H. Jessen Jürgensen, nods in recognition of this. ▶

► "If we have had any problems with the T2, it had to have been self-inflicted. I would venture to say that it is the most successful Danfoss product ever. Equivalent valves have been produced in many other places around the world, but it is the T2 that we sell, and we have had no problems with it. It is a key component in the plant, because it is just as important as the compressor."

Jan Lund started with H. Jessen Jürgensen in 1980. The company was originally located in Frederiksberg, but when the buildings burned down, they had to find something new in a hurry and moved to Ballerup. The head office is still in Ballerup, but they also have branches in Hasselager and Kolding. H. Jessen Jürgensen was sold in 1998 to Beijer Ref.

Over the years, H. Jessen Jürgensen shipped several hundred thousand T2 valves to refrigeration companies in Denmark, and according to Jan Lund, working with Danfoss has always been a pleasure. He has 35 years of experience with the T2 and can only share the enthusiasm that employees at Danfoss have for valve.

"The T2 has gone virtually unchanged through all the challenges it faced over time. From the outside, it is the same concept, and it is great to work with. Over time, it was developed further for the new refrigerants that appeared, and I can say this very simply: Product continuity is good news in our industry, and this applies to the T2 as well. It is very good quality, it is easy to use, and it is reliable."

Jan remembered that in the beginning there were a lot of problems with getting customers to understand how to install the T2.

"With all due respect to our customers, but when the T2 came out, they were not as informed as they are today. The biggest problem with thermal valves in the beginning was getting people

to understand how the valves worked. Many thought that it was a water faucet that they had to turn. They did not quite understand that it was the interaction between the pressure and temperature, which opened and closed the valve."

"The challenge is to adjust it correctly. The valve is a critical product in the refrigeration system because, if it does not work properly, it results either in a poor operating economy, reduced compressor lifetime, or in the worst-case scenario, compressor damage. Whenever the valve has caused compressor damage, it was not the valve that was at fault, but either an error in sizing or a maladjustment. The valve may lose refrigerant charge, but it is fail-safe in the sense that if it loses the charge, which is the most common fault, then it just closes. It does not damage anything, but then of course neither does it refrigerate. But oh no, the customer must under no circumstance start turning it. It is important to understand the product. This is why today I am really pleased with all the tools and e-learning that Danfoss offers completely free electronically, such as Coolselector. It has made a big difference to the industry. It was also very helpful that the T2 came with a small case with the appurtenant nozzles. This made the work really easy for the installers, and this is largely why it was such a great success both for Danfoss and for us."

With the assistance of the T2, Jan makes sure that items in countless supermarkets are kept cool and avoid food waste. The valve has also been used for numerous other more or less exotic refrigeration functions.

"After all, the T2 is a simple and ingenious product that is found everywhere. Its simplicity, longevity, and serviceability are great. It is also why it has endured for so many years. Like a hairpin, it rarely breaks. But the comparison with a hairpin may underestimate it a bit because it is much more advanced. But for us wholesalers, the only problem with the T2 is that they seldom break. They are simply too good, and that is not what we wholesalers make money on. There should be a bit of replacement," Jan said, laughing.

2016

ENGINEERING
TOMORROW

Engineering Tomorrow

In March 2016, the T2 valve turns 50 years old and in that very same month, the 50 millionth T2 valve will roll down the production line. According to Senior Vice President of the Commercial and Air Conditioning business at Danfoss, Stephen Gugliotta, this is nothing short of amazing,

"In the years since its initial release, the T2 has proven to be a game-changer for Danfoss attributed to its massive success in the market. Today, the T2 remains the single highest produced expansion valve for Danfoss with production locations in Denmark and China. It continues to be sold worldwide for use in a variety of refrigeration and air conditioning applications. Throughout its long lifetime, many competitors have tried to copy it. However, no valve has surpassed or outperformed the Danfoss T2, which is expected to enjoy continued market success for years to come."

Many innovative products, technologies, and solutions have come along in Danfoss' endeavor to help meet the world's growing challenges in infrastructure, safe food supply, energy efficiency and climate friendly solutions.

"The tale of the T2 has been a vital contributing factor. It is a very energy-efficient product and has only needed a few modifications over the years in order to remain compliant with

> *The energy savings of T2 could power Argentina for over a year.*

Stephen Gugliotta

changing environmental demands. Over the past 50 years, the T2 valve alone has saved approximately 157,000 GWh in the thousands of applications where it has been installed. To put this in perspective, the energy saved could power Italy for six months, Denmark for nearly a year or Argentina for over a year," Stephen Gugliotta continues.

With the T2's long history as a safe and reliable choice for our customers, it has served as the foundation for further expansion valve innovation. The TU expansion valve, launched in 1995, was the first of its kind made of stainless steel. Incorporating innovative bi-metal connectors which eliminates wet wrapping during installation, the TU continues to be the most compact and lightweight valve in the market. Continuing with this trend, later this year Danfoss will launch the first ever hermetic stainless steel electronic expansion valve, ETS Colibri®, targeted for use in air conditioning applications where the need for improved energy efficiency is ever increasing.

After 50 years, the T2 valve continues to remain a fundamental part of our expansion valve program. It has held its position of superiority in the market because energy efficiency, quality and reliability have always been top priorities for Danfoss. This is what we call *Engineering Tomorrow*.

The T2 through the years

1933 — Manufacturer Mads Clausen founds the Danish Refrigeration Controls and Apparatus Manufacturer.

1934 — Sketch of the first valve.

1950s — Mads Clausen's travel reports from the United States and other places draw inspiration from competitors.

Late 1950s Early 1960s — Commercial refrigeration develops rapidly (everyone has refrigerators, icemakers, and freezers).

1954-67 — The TVJ valve.

1966 — Knud G. Hein finalizes T2, and it quickly gains a foothold in the market.

Technology leaps (from the bellows to the membrane valve).

1986 – Introduction of the service case.

1987 – Production of T2 number 10,000,000.

1994 – Expansion for fully automatic production at L3 (*Langelinie*).

1994 – Technology changes to the T2: Nickel removed – capillary tube of stainless steel.

Date: 08.08.2008 at 8 a.m. – Initiation of production in China.

2014 – Production of 3,000,000 in China.

Week 11 2016 – Production of T2 number 50,000,000.

Week 11 2016 – 50 years' anniversary.

Behind the book

At a time when connectivity, big data, cloud-based, and internet of things take up a part of everyday life at Danfoss, for some it may seem a bit old school to write a book about a mechanical valve. But not for me. The journey I have embarked upon with the T2 has been fun, amazing, and educational, and this book has thus brought people and information together from all over.

First and foremost, this book is intended for anyone who wants to read an industrial fairy tale. However, it is targeted especially at the people behind and around the T2, and how their 10, 20, 30, or almost 40 years of experience with the valve has affected what the valve has become today and how it has managed to endure despite the rapid development taking place just outside the window. The book is dedicated to engineer Knud G. Hein and the designers who created the T2. But also to the installer who bent the valve with an elongated wrench, the manufacturer who wanted to make the world's best gourmet ice cream, the wholesalers, the engineers, the designers, the marketers, the production personnel and account managers, and of course: The little lady who swept the new production plant in China every day, so that dust did not get into the equipment.

It has been virtually impossible to find any negative information on the T2. No matter how many customers I have asked, no fault has been attributed to the T2. It is quite unique for a 50-year-old product, and thus an even bigger reason to celebrate the T2's 50th birthday.

Congratulations to the little golden egg.
Trine Kiær

ENGINEERING
TOMORROW

Thanks to

Bitten og Mads Clausens Fond
Danfoss Museet
Sønderborg og Nordborg Bibliotek
Massimo Alotto
Ejner Kobberø Andersen
Svend Carl
Alberto Corelli
Henrik Denning
Inger Dethlefsen
Finn Fastrup
Stephen Gugliotta
Tina Holst Helledie
Chrestine Hermansen
Jens Jensen
Stig Jensen
Tommy Due Jensen
Svend Stuhr Jepsen
Tommy Jozefowicz
Roberto Lazzarini
Chang Lianhe
Zhigang (Jeff) Liu
Jan Lund
Torben Matzon
Georg Meister
Christian Mortensen
Jonna Neumayr
Jan Ohlsen
Kaj Ohlsen
Lars Otten
Jørgen Trelle Pedersen
John Porland
Lone Pustelnik
Jan Schoemaker
Glenn Shermer Simonsen
Dorthe Borup Sindberg
Lisa Tryson
Anders Vestergaard
Steen Weile
Lun (Jackie) Xiao
Gang (Jason) Zhao
Production workers in Denmark and China

ISBN: 978-87-998907-0-5