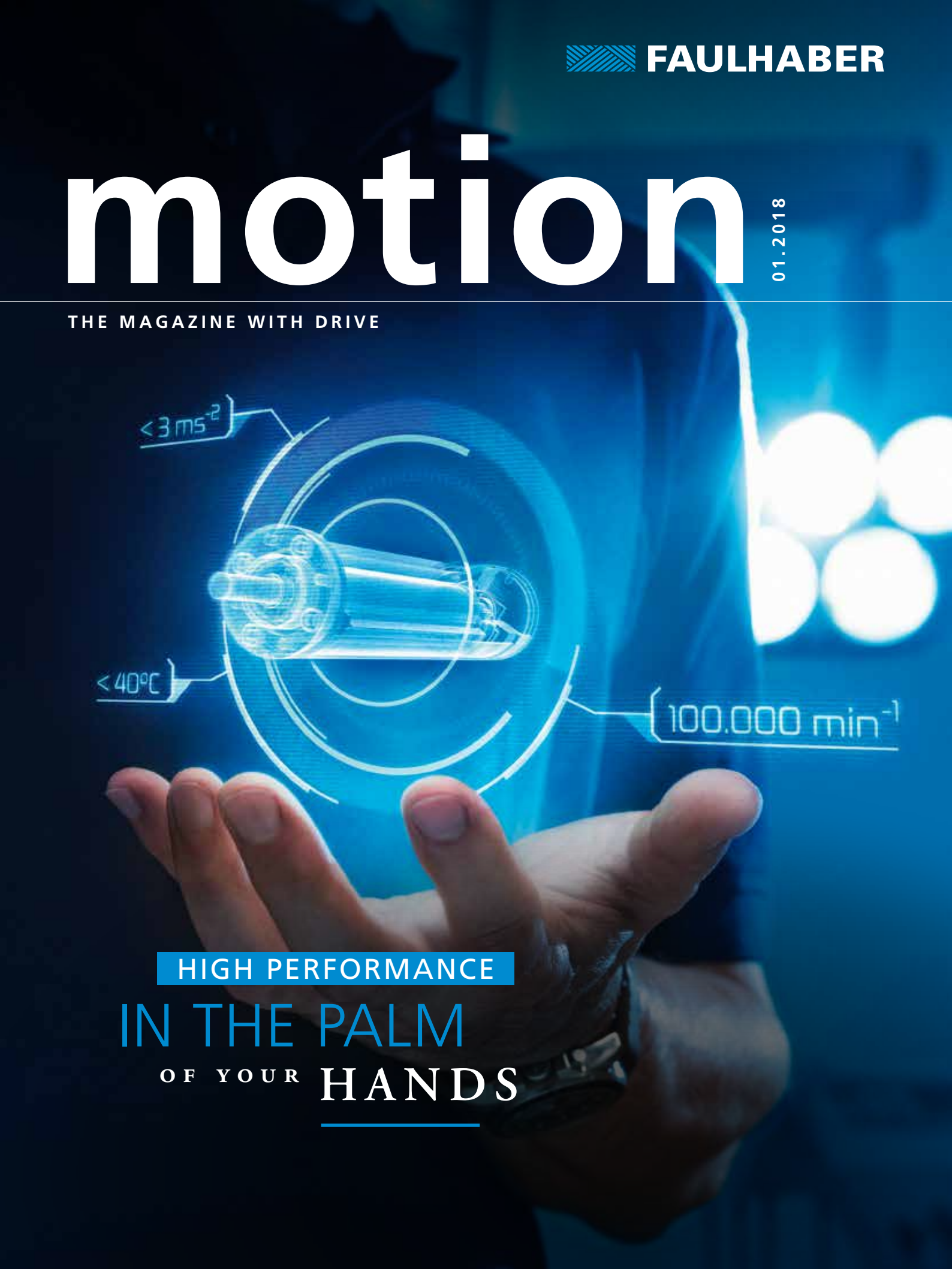
FAULHABER

motion

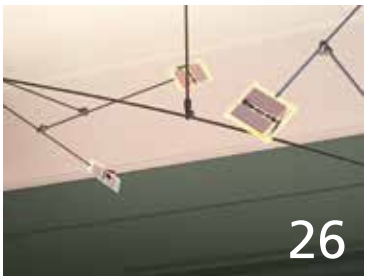
01.2018

THE MAGAZINE WITH DRIVE



HIGH PERFORMANCE

IN THE PALM OF YOUR HANDS



Dear readers,

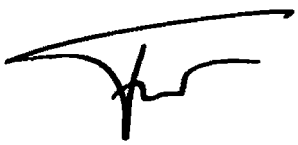
Modern medicine performs amazing things and helps to sustain and protect life every day. Especially with premature babies, it is essential that the conditions absent from the womb be simulated with an incubator in the best possible manner. Constant warmth and consistent humidity are just as important here as a quiet environment to protect the sensitive body and organs from damage and thereby facilitate normal development. Manufacturer Tende Elektronik therefore counts on reliable and extremely quiet brushless drives from FAULHABER for its incubators. Our DC motors also function as 2-way teams on many shorelines, where they reliably and very precisely ensure the unique flashing sequence of countless lighthouses in place of the previously used tower clock drives.

FAULHABER drive systems for movement – everywhere in our lives: whether increasing the sound volume of a piano, ensuring that a pair of shoes ordered online match those that are delivered, instilling enthusiasm with nature-inspired, ecologically driven art – precision and power in the smallest of spaces always achieve great results.

Learn more in the exciting reports, portraits and interviews of this issue of FAULHABER motion – the magazine with drive.

I wish you a good read!

Sincerely



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www.faulhaber.com/motion

A STEP AHEAD FOR 30 YEARS

FAULHABER PRECIstep is celebrating its 30th anniversary: in 1988, Messrs Arnoux and Richard founded their company Arnoux Richard SA Porte Echappement or "ARSAPE", in La Chaux-de-Fonds, one of the world's capitals of the Swiss watch industry in the canton of Neuchâtel in western Switzerland.

30 YEARS OF STEPPER MOTORS

Established as a management buyout for the purpose of taking over the manufacture of clock drives, the first 1- and 2-phase stepper motors were designed with a performance/volume ratio and level and a precision that were a step ahead of conventional drive technology. These were motors that could drive larger systems electronically and above all much more precisely than previously possible, and they were sought after not only in the watchmaking industry. The product range was continually expanded, and the workforce grew rapidly with the increasing demand for high-end stepper motors from the 12-person staff who initially joined the founders.

So in 2001, it was a logical step for FAULHABER to expand its technological portfolio and become a stakeholder in ARSAPE in order to integrate the stepper motor specialist in the FAULHABER Drive Systems company group. ARSAPE was renamed to FAULHABER PRECIstep SA in 2012. After many years in a tradition-rich building that was typical for watchmakers, the growth of the company was also mirrored in a relocation: In 2015, the company moved to a larger, modern industrial building in order to continually meet the required production standards as the leading company on the market for high-quality miniature stepper motors.

FAULHABER PRECIstep now produces 2-phase permanent magnet stepper motors with diameters from 6-22 mm. The tiny actuators with an impressive performance-volume ratio are contributing to the trend towards miniaturization in many sectors. In conjunction with the zero backlash gearheads from FAULHABER Drive Systems, to be replaced by "they allow to reach points of operativ that remain unmatched by the other solutions available on the market." The highest quality standards guarantee maximum, durable performance. Another added value is the fact that FAULHABER PRECIstep can also precisely adapt its drives to customer requirements. The application possibilities are accordingly broad: from optics and photonics, especially in the medical sector, to aerospace, which require absolute reliability well beyond 10 years, in addition to performance. No wonder stepper motors from FAULHABER PRECIstep will be part of the next rover expedition on Mars in 2020. But first, FAULHABER PRECIstep is celebrating its 30 years of success in La Chaux-de-Fonds, Switzerland, on 22 June 2018.

FURTHER INFORMATION

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www.faulhaber.com

Presto
FORTISSIMO

Nowadays, concert pianists are required to render top athletic performances. Particularly when it comes to major piano concerts, pianists often explore the outer boundaries of finger strength and concert piano mechanics. Physicist and amateur pianist Dr Antoine Letessier-Selvon aims to push these limits - with the help of a linear motor from FAULHABER.

You are a well-known particle and astrophysicist who works primarily in cutting-edge research. Where does your interest in playing piano come from?

Before I decided on physics, my goal was to become a concert pianist. My children play the piano, and we have a grand piano in the middle of our apartment. This particular instrument needed some adjusting, and that's how I met Laurent Bessières, the piano tuner of the Paris Philharmonic. We talked about piano mechanics, and he asked me as a physicist if there was a way to give the stroke more force.

Why does the stroke need to be more powerful?

When Mozart and Beethoven performed their piano concertos, their audience comprised a couple of hundred people at the most. Today, we have concert halls that can accommodate up to 2,500 visitors. The orchestras have also become bigger and louder. Yet the mechanics of the piano have practically remained unchanged for more than a hundred years. Especially for fast passages that are very loud or quiet, the boundaries of physics are exhausted. The pianist is simply unable to vary the tone beyond these boundaries.

What defines these boundaries?

Even with the most extreme training, there is a natural limit to the force that fingers can exert. Secondly, the mechanics of the piano are subject to physics. The most important elements in this regard are the stroke path of the key, secondly the lever ratio with which this path is transmitted to the movement of the hammer, and thirdly the weight of the hammer. The stroke has indeed been extended over time, from about seven millimetres to one centimetre. That is the maximum in order for the pianist to still be able to play fast passages. The lever ratio of five is mostly invariable for design reasons. And with a weight of ten to twelve grams, the hammer has also reached its limit. More weight would encumber the playing inertia.

To what extent can the limits be expanded?

The idea is to completely separate the generation of sound from the stroke and to introduce a mechanical power source instead. This is what I proposed to Laurent Bessières, and this was the direction we started looking into. Finally, I found the LM 1247 linear motor from FAULHABER online after sorting trough innumerous unsuitable models. This drive was very powerful and had just the right dimensions. Its width precisely matches that of a piano key! A couple of millimetres more or less would also be feasible, but details like these sure give you a sense that this is the perfect match.

What came next?

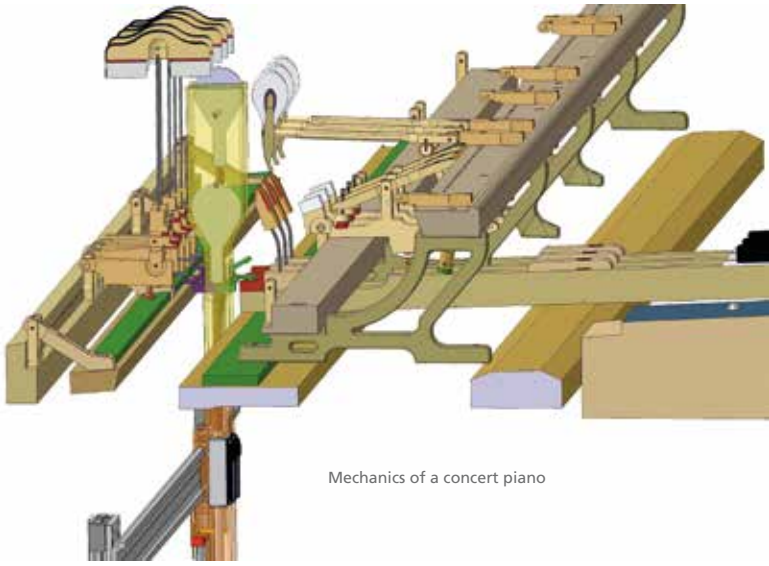
In recent years, we were able to start a research project at Centre National de la Recherche Scientifique. As head of research at the CNRS, I have access to excellent specialists in electronics and mechanics who can contribute significantly to making our idea a reality. And, by the way, they surely would have told me right away where to find the right motor, if only I had asked. We were also fortunate enough to get the support of piano maker Stephen Paulello, who is well-known in his field for his extraordinary innovations and who helps us in many regards.

How does it work from a technical standpoint?

We fasten an acceleration sensor to the hammer handle, which moves due to the pressure applied to the piano key. It records the movement of the stroke very precisely in terms of force and speed. Its signal is transmitted by the electronic control to a linear motor. The motor translates this into a hammer movement with very high precision. The hammer is situated on the axis of the motor, in the same location below the string, just like in traditional mechanics. I would like to point out that we are not endeavouring to design a self-playing mechanical piano - that already exists. Those produce sound, but not real music. Instead, we aim to support the pianist and facilitate new possibilities. The artist has full control over the sound. We call this an assisted piano.

What are the benefits of this assistance?

The external source of energy allows us to change a few things. The weight of the hammer can be easily increased to fifty grams or more. A heavier hammer produces more volume, and it can trigger a wider range of overtones due to the greater force. We can dynamically change the lever ratio between stroke and hammer path, for example by introducing a fourth pedal, thus increasing or decreasing the force of the "lever arm", i.e. the motor. This gives the pianist entirely new possibilities if he or she wants to play extremely fast passages very quietly or very loudly. We can adapt the keys' path to the artist's preferences. A piano tuner can replace all hammers in about ten minutes, adapting them to the pianist's needs. With conventional mechanics, such a reconfiguration would entail many hours of work.



Mechanics of a concert piano

Isn't there a delay between the stroke and the sound due to the interposition of sensor, control and motor?

Actually, it's the other way around. Conventional mechanics are subject to considerable inertia. When playing softly, for example, the hammer moves about 0.5 metres per second, while that number is tenfold with fortissimo. This factor of ten is not an issue for the pianist. The keystroke alone takes about ten milliseconds when playing very quickly, and accordingly longer when playing slowly. The reaction time of the motor will be clearly below ten milliseconds, probably even under one millisecond. Our electronics also react in the micro-second range. FAULHABER measured the longest interval in our system, which is the delay that occurs between the controller outputting current and

the motor standby current. This is in the range of just a few hundred microseconds, so clearly below a millisecond. I am certain that the pianist will not perceive a delay.

Where are you now at with the research project?

Last year we started with a monochord, which is just a single string, in order to check the feasibility of the technology. Since then we know for certain that we have found the right acceleration sensor and motor. FAULHABER has developed an acceleration-oriented control that suits the instrument better than the traditional speed controller. We are now in the process of working out the details of the assisted mechanics. By June, we aim to cover an octave, which is 12 notes. Once we get to that point, we will fit the entire grand piano with the assisted mechanics. Hopefully, we can have the first concert next year.

How important is the motor to the project?

Without it we wouldn't have been able to even start. Until a few years ago there was no motor with the performance characteristics that we required. The motor has to be very powerful despite the small dimensions, accelerate extremely quickly, and it must be controllable with high precision. And notwithstanding all of that, it must operate completely silently. It was only the development in neodymium permanent magnets in recent years that has made such a motor even possible, and of course also the development work by FAULHABER.

FURTHER INFORMATION

INSTITUT LAGRANGE DE PARIS
WWW.ILP.UPMC.FR

FAULHABER
www.faulhaber.com

BEACON LIGHTS OF THE MODERN AGE

Lighthouses: The structures may appear old and dignified, but the technology inside is modern and robust. Availability as well as low operating costs with long maintenance intervals are the decisive criteria when selecting lamps and the electromechanical design. Anyone who takes a look inside a lighthouse along the French coast has a good chance of experiencing drive technology from FAULHABER.

France is the land of giants. Nowhere else on earth are there so many lighthouses along the coast that stand as tall as 80 metres. The impressive structures are not necessarily due to the fact that the sections of France's coastline are particularly dangerous. Rather, the large and rich decorations of the buildings stem from the self-confident national pride – and create publicity for themselves. When I think of lighthouses, I think of Henry Lepaute. The name comes to mind as soon as one mentions the technology used in these maritime navigation marks. Lepaute builds the optics that ensure that the light can be seen from distances as great as 40 kilometres. 23 nautical miles – the beam from the lamp room must be visible at least this far away.

The distinctive lighthouses with buoys, satellite navigation and radar are part of a quartet that gives skippers the necessary orientation. Particularly in areas near the coast, visual navigation signs cannot be replaced by anything else. The density is especially high in France along the Channel coast due to the enormous tidal differences in the water level. Some 120 lighthouses with rotating light are operated, monitored and maintained in the Grand Nation by the governmental agency Cerema – and used very often in these lighthouses are the optics produced by Henry Lepaute, which in turn are based on the basic research conducted by Frenchman Jean Augustine Fresnel on the wave theory of light. The result is a lens comprising up to 20 ring-shaped sectors with a focal length of up to 700 millimetres. The lenses refract the light that is emitted in all directions on a horizontal plane, thereby making it visible from a great distance.

The typical flash of the lighthouses can be achieved with three technical methods: through constant lighting with a flashing light, a constant light source with rigidly arranged lenses and a circumferential aperture as well as – the most common variant – the combination of continuous light and a circumferential lens system.

In the course of ongoing modernisation, Cerema makes use of LED technology – thereby benefiting from the advantages afforded by a long-lasting and robust lighting system. According to information provided by Cerema, an availability rate of approximately 99 percent is achieved. "We would like to reach this level of operation reliability for the drive of the rotating optics as well", emphasises Laurent Bernicot from the department for navigation and positioning systems at Cerema. "Reliability was a very important criterion for the choice of drive – and led us to FAULHABER."

The result of the design with manufacturer evaluation: DC-micromotors of the FAULHABER 2342 and 3257 series as well as brushless DC-servomotors of the 3268 series – each combined with appropriately matched FAULHABER planetary gearheads. In addition to the general functionality of the drives, intensive test runs served to determine their behaviour in salty air. "We have lighthouses on land and at sea. The drives need to operate reliably there as well – and not only in France itself, but also in French Guiana or the Overseas Collectivity of Saint Pierre and Miquelon off the coast of Newfoundland."

Double drive for maximum operation reliability

With respect to design, the high demands on operation reliability are reflected in a drive unit with two motors – an arrangement also found in German lighthouses. "Two motors are connected to one gearhead and run alternately", explains Dirk Berger, spokesperson of the Stralsund Waterways and Shipping Office. The alternating operation harmonises the operating hours and ensures availability, as longer periods of downtime often lead to start-up difficulties. Should one motor fail, the system in the lighthouse automatically switches to the second motor and reports the malfunction to the control centre. "We use remote monitoring, particularly with the large lighthouses", reports Berger. A two-stage escalation level is integrated in the control here: prewarning in the event of impending malfunctions and failure.

Reliable operation is monitored with a sensor that measures the time per revolution. "The lighthouses must turn at the exact speed specified in their identifier", says Dirk Berger. Hidden behind the identifier is a special type of flash sequence that is listed in the nautical charts and, particularly when navigating at night, allows a lighthouse be unmistakeably identified. "Our goal is therefore to achieve a constant rotational speed on the optical level", explains Berger's French colleague, Laurent Bernicot from Plouzane in Brittany. "Thus, our motors must be precise."

The French lighthouses use a control developed by the EMF department at Cerema. The abbreviation stands for eau, mer, fleuves – or water, sea, river. The intelligence in the lamp room specifies how frequently and at what rate the light is to be visible within a given unit of time. As in Germany, a sensor measures the rotational speed of the optics and transmits the information to the control. After performing the calculation, the controller adjusts the motor speed via the analogue set value directly with the motor supply voltage. The speed is constantly monitored and adjusted. Should a problem be detected, the automation solution provided by the EMF department saves the error and starts the second motor.

DC-MICROMOTOR
3257 … CR series
∅ 32 mm, length 57 mm
Output torque 73 mNm

Should one motor fail, the system in the lighthouse automatically switches to the second motor and reports the malfunction to the control centre.

During the design process, the EMF employees selected three different motor types as the standard drive solution. The DC-micromotor of the DC2342 series is tailored for small optics that require only low motor power. Medium-sized optics are put into motion by the graphite-commutated motors of the FAULHABER DC3257 series. For powerful systems with high light intensity and correspondingly heavier construction, the brushless, four-pole servomotors of the 3268 series are used. When Laurent Bernicot speaks of "heavy systems", he is referring to a lamp optics system with a mass of between 200 kilogrammes and one tonne.

During design, it is therefore important to ensure that, apart from normal operation, the motors deliver powerful peak torques in order to safely handle the high starting torques of between 5 and 8 Nm. "This was also an important factor in selecting the FAULHABER motors", explains Bernicot. If, however, a standstill occurs because the lighthouses are only operated at night, the optics are decoupled from the motor via a freewheel integrated in the rotary machine when the lamp is stopped.

The bottom line

With respect to the high requirements on availability with long maintenance intervals, the framework conditions in a lighthouse are demanding. This is why it is so important to maintain a close project partnership. Cerema and the FAULHABER's French subsidiary have been working closely together since 2011.

From clock-tower drive to high-precision electric motor

Over a hundred years ago, lighthouse optics were still driven by a clock-tower drive. From a design standpoint, this was, in fact, a modified mechanical clockwork for churches that had to be regularly wound up with weights by the lighthouse keeper. "The first electric drives appeared in the 1930s", reports Dirk Berger, spokesperson of the Stralsund Waterways and Shipping Office. Another modernisation wave started in the 1980s. The technology is still in operation today. The long service life is the result of regular maintenance and operation at well below the maximum available torques.

FURTHER INFORMATION

FAULHABER
www.faulhaber.com

WARMTH Rest COMFORT

If a child is born too early, its development has not yet been completed in the womb. Providing it with the protective environment needed to catch up is an incubator, such as those available from Tende Elektronik. The medical technology specialist from Ankara relies on fan motors from FAULHABER for air conditioning in the incubators.

A normal pregnancy lasts 40 weeks. During this time, the baby gets everything it needs in the womb. It receives oxygen and nutrients through the umbilical cord; the amniotic fluid and the body heat of the mother ensure the ideal temperature. The mother's movement and touch as well as noises from the body and the outside supply the sensory input that is so important for the development of the brain. A premature birth robs the foetus of these important resources.

Thanks to modern neonatal medicine – the term for the medical care of premature infants – babies still have a good chance of surviving outside of the womb from the 25th week of pregnancy. Approximately 80% of preemies can even make up their growth deficit within the first two years and develop fully normally.

Constant warmth crucial for survival

In the first weeks and months, however, they need comprehensive care and the protective environment of an incubator. The incubator simulates the physiological conditions normally present in the mother's womb. In addition to various possibilities to provide assistance with feeding, it offers above all a pleasant and constant warmth as well as consistent air humidity.

These are decisive parameters, as the organs of the child are – depending on the time remaining to the normal due date – more or less significantly underdeveloped. The small body is not yet able to regulate its temperature itself. Furthermore, the lungs often need enriched air to absorb enough oxygen.

"The incubator is supplied with air that is at exactly the right temperature and humidity," explains Ferhat Yıldız, CEO at Tende Elektronik. "The air is transported into the incubator by as if an impeller, i.e., a propeller enclosed in a housing. As a result, this fan is a decisive component for the function of the incubator and for the well-being of the baby."

But the impeller needs to do more than just supply a constant flow of air. After all, the incubator cannot remain closed all of the time. To care for and treat the baby and – of course – for the ever so important body contact with the parents, it is regularly opened completely or partially. The fan then provides an "air curtain", which largely prevents the penetration of cooler air. At the same time, it supplies more warm air to compensate for the nevertheless unavoidable drop in temperature. The speed of the impeller therefore also regulates the temperature in the incubator.

Quiet technology prevents hearing damage

The fan and its electric drive are, however, a noise source that is located very close to the small body. Like the other organs, the ears of the preemie are not yet fully developed, making them especially sensitive. If the noise level rises above a certain, relatively very low value, there is a risk of permanent hearing damage. Because the impeller runs continuously, its operating noise must be considerably below this value.

There is, thus, a clear requirement on the drive: it must run as quietly as possible. The FAULHABER motor achieves this thanks to – among other things – it's ironless design, which eliminates cogging torque: the "jerking" on every revolution that is unavoidable with electric motors with iron armatures cannot occur here. In addition, the noise of the electromagnetic interference is minimised by an integrated speed controller. Because another noise source is the so-called pulse width modulation (PWM): this is used to switch the power supply of the motor on and off in very short intervals. The pulse width – the distance between the switching operations and their corresponding duration – influences the speed and makes precise control possible. The PWM can, however, cause a humming noise. With the brushless DC-servomotors used here – 2232...BX4 SC for stationary and 3153...BRC for mobile incubators (both models with integrated Speed Controller) – the so-called electrical noise is avoided by the very high frequency of the PWM as well as by foregoing a separate lead wire between motor and electronics.

Electric drive for incubators

"Also decisive for minimising the noise is the perfect balance and the tight tolerances of the individual parts," explains Tiziano Bordonzotti. At FAULHABER, he coordinated the cooperation with Tende Elektronik and organised the development of the customer-specific solution. "The outstanding running characteristics of the motors are the result." The exceptionally low noise level of the Tende Elektronik incubators of 42-45 dB, which corresponds to a whisper or quiet music, is largely thanks to these motors. An integrated speed controller ensures the precise and reliable control of the drives. This, in turn, helps keep the units very compact and lightweight, which is especially important with the mobile incubators.

Certification for medical technology

Ferhat Yıldız praises the cooperation: "FAULHABER provided us with comprehensive support and developed what is for us the ideal drive. The high quality of the motor matches the high quality of our incubators. Another advantage for us stems from the fact that the production facility for the motor possesses the necessary ISO certificates for medical products, allowing us to install these components without additional certification effort."

Tende Elektronik, explains CEO, began producing incubators for premature babies for other firms as an OEM supplier in the 1990s. The company, which is based in the Ankara Technopolis of the University in the Turkish capital Ankara, has produced under its own name for the past three years. It now exports its products to dozens of countries. This success, Yıldız is certain, is related to the clear focus on quality and innovation: "We are, for example, the first company in the world to directly integrate Masimo Rainbow SET technology to incubators. This enables very sensitive, non-invasive monitoring of the body functions of the newborn."

In addition to the well-being of the small patient, yet another aspect plays a decisive role. The incubator is in operation around the clock and the neonatal clinics want to use the devices over long periods of time. "We are aiming for an operating life of at least ten years," says CEO. "The components – i.e., including the motor – must perform their work for a very long time with maximum reliability. With the FAULHABER motors, we know that they are capable of doing this."

BRUSHLESS DC-SERVOMOTORS WITH INTEGRATED SPEED CONTROLLER

2232 ... BX4 SC series
∅ 22 mm, length 32 mm
Output torque 17.5 mNm

FURTHER INFORMATION

TENDE ELEKTRONIK
www.tende.com.tr

FAULHABER
www.faulhaber.com

SMART LOGISTICS

Microdrives and Motion Controllers from FAULHABER are what make the TORU picker robot from Magazino so versatile. With an eye to the constantly growing sector of online retail, logistics and material flow are coveted playing fields for technical progress – with the goal of increasing efficiency through automation and digitalisation. Magazino, the still-young company from Munich, has set out to intelligently combine autonomous driving and robotics with one another. The solution is called TORU and has what it takes to revolutionise logistics. For the handling operations in the self-driving logistics robot, Magazino uses drive solutions from FAULHABER with integrated Motion Controller.

Their vision is clearly formulated: Magazino aims to create the world's first self-thinking and self-acting warehouse – and is well on the way to doing so. The new logistics robot is called TORU and is currently proving itself in practical tests with major shipping service providers. These use the intelligent, self-driving system above all for retrieving shoeboxes during order picking. Conceptionally, TORU is a so-called perception-controlled robot. Through the use of cameras, image processing, sensors and artificial intelligence, it is able to perceive and correctly interpret its environment and use this as a basis to make decisions.

Robot creates its own picture of its surroundings

Make decisions? When TORU receives an order to pick a certain pair of shoes, it is first given the warehouse address plus a bar code. Thus, the robot knows where the target bin must be located and navigates right up to the address. The lifting column at the front of the vehicle then rotates 90 degrees towards the shelf, a gripper moves to the specified bin and now TORU begins to make decisions on its own. Using three-dimensional camera images, the robot first produces a picture of the current situation. "Is there even a shoebox on the shelf? Is the right bar code present? Am I able to grip the carton: perhaps it was moved a couple centimetres to the side and would jam when pulling out?" With these questions, Magazino spokesperson Florin Wahl describes the primary tasks of the visual analysis. It is the answers that make the system from Munich so unique. If a picking order is linked to a carton that was placed on the shelf somewhat askew by an employee, the robot attempts to adapt its gripper process to the circumstances. If TORU ascertains that gripping is still not possible, the job is returned to the system – and a warehouse employee would need to perform the order picking by hand.

TORU picker robot in use

If no problems are detected, it is above all drives from FAULHABER that are responsible for handling the shoeboxes. Here, Motion Controllers, brushless DC-servomotors of the BX4 series and planetary gearheads form a drive system that extends and retracts a metal tongue. The task in this case is to close the gap between the vehicle and the bottom of the shelf. The path is thereby levelled, allowing the cartons to be pulled out on the flat surface with negative pressure.

High overload behaviour

For the positioning of the suction gripper along a toothed rack, Magazino uses type BX4 drives from FAULHABER. With a power of 62 watts, the brushless DC-servomotors deliver rated torques of up to 72 mNm in continuous operation. Interesting for Magazino are the peak torques of up to 96 mNm. The overload capability is decisive for overcoming the breakaway torques when handling the shoeboxes. "We need motors with high power density," explains Raphael Vering from engineering development at Magazino. Because the peak torques are only called for in a very narrow time window, there is no risk of the motors becoming too hot.

BRUSHLESS DC-SERVOMOTORS

3268 ... BX4 series
∅ 32 mm, length 68 mm
Torque 96 mNm

FURTHER INFORMATION

MAGAZINO GMBH
www.magazino.eu

FAULHABER
www.faulhaber.com

Smaller drives

The powerful overload behaviour of the motors – with their diameter of just 32 millimetres – offers the Munich logistics pioneers a number of advantages. The design provides the basis for being able to use smaller motors through the reliable handling of the breakaway torques. The result is that smaller drives are inherently lighter. "The mass of the gripper needs to be as low as possible because it has to be moved along the vertical axis with TORU," explains Raphael Vering. The heavier the gripper unit, the greater the required motor power of the vertical axis. Then there is the question of the centre of mass when TORU needs to grip a shoebox located on the top level of a two-metre rack.

Without question: the centre of mass can easily be shifted downwards by using a thicker base plate. This, however, makes the travel unit heavier. As a result, a stronger drive motor is needed. This, in turn, requires more power from the battery, thereby reducing the range. A lightweight design is also necessary because TORU is to be used not only on solid concrete on the ground floor, but also on more delicate ceiling constructions of intermediate levels. "Here in particular, the surface loads are very limited. We want to make TORU as versatile as possible, however," notes Florin Wahl. Larger motors would also inhibit handling – especially when cartons are stored just a few centimetres above the floor and it is necessary that the drives simply not be in the way. With the FAULHABER solution, Magazino is able to move down very low and up again. "This is extremely important when we consider the capacity of a warehouse with respect to the floor area. Every additional shelf space is worth gold," summarises Florin Wahl.

The idea behind TORU lies in the implementation of a sophisticated system of automation, robotics, vision and autonomous driving. When evaluating the drives, Magazino was therefore in search of solutions with optimum power density. These in, turn, must be capable of being elegantly integrated in the existing automation concept. "Support of CANopen communication was decisive for us," reflects Raphael Vering. Because the Munich firm was also able to use a perfectly fitting, complete Motion Control system from FAULHABER, the development department had more freedom for further optimisations of the new logistics solution. "We don't need to invest any time in our own controllers or in the integration of encoders," emphasises Vering. With the DC-servomotors, the FAULHABER Motion Controllers of the V2.5 generation form highly dynamic positioning systems. For feedback control, Magazino uses analog Hall sensors, thereby eliminating the need for a separate encoder for feedback. The integrated current control of the Motion Controllers limits the torque and thereby protects the electronics and motor from overload. Magazino, in turn, uses this function to detect faults in material flow – such as if a shoebox has jammed in a shelf compartment, causing the removal unit to stop.

SIMPLE, SAFE AND EFFICIENT

The bottom line

With TORU, Magazino has succeeded in developing a material handling solution that can simply and reliably improve efficiency in logistics. The current employment situation in Germany makes the potential offered by this invention clear. Labour is in short supply – especially at night and on weekends. But this is when most online shopping takes place. The use of autonomously and intelligently acting logistics robots would be a way to at least prepare order picking at the start of the week. For this purpose, TORU is equipped with a travelling shelf into which the removed boxes are inserted. Centring units with FAULHABER drives help to position the boxes in a space-saving manner.

HIGH PERFORMANCE

IN THE PALM OF YOUR HANDS

When the dentist prepares the foundation for a crown or the watchmaker adorns the barrel with a decorative touch, both experts are working freehand with a powered machine. They perform these tasks daily and often for hours at a time. The slightest variation in weight of the tool's handpiece that they must hold during this time makes a difference in comfort. But the device should still have a powerful and robust high-performance motor that can work quietly and without disruptive vibration. The new 1660…BHx series from FAULHABER is setting new standards on this point, and it yields the greatest torque from this motor format compared to market competitors.

It wasn't all that long ago when handpieces for delicate one-handed tasks were supplied with an external drive source. The handpiece with integrated drive unit was simply too heavy to hold with one hand while at the same time moving the tool with a high degree of accuracy. So the motor was put in a box and the drive power was transmitted to the rotating tool via flexible shafts. One drawback was that the shafts had their own intrinsic weight, and their low flexibility dramatically limited the range of movement and power efficiency. And the same is true for the pneumatic variant, where the tool is operated with compressed air which results in more noise and less precise control. However, this variant is not feasible for medical applications to begin with.

Patients benefit from motor performance

The rapid development in motor technology in particular is the reason why such shaft-driven handpieces are nowadays only admired in technology museums. Today's successors get their Power from small electric motors that fit conveniently into common housings. Combined with the latest high performance batteries, they can even do without electrical lines. For use in the medical field,

robotics, lab equipment or the watchmaking industry, the motor with a diameter of 16 millimetres has established itself as the standard. These drives have been used for many years, and they have proven themselves in the handpieces of various machinery.

But as soon as a new standard is achieved, new requirements emerge once again. Advancements in medical science, such as for dental treatments or musculoskeletal operations, enable increasingly comprehensive treatment options. This may require very lengthy treatment, which can be highly taxing on the physician. Even the machines used are often required to work extremely hard during frequent use.

New knowledge, methods and systems now ensure that difficult treatment procedures can today be performed successfully and with minimal discomfort for the patient. New powerful and lightweight hand tools using modern drive technology have made a significant contribution to this.

Electromagnetic principles rethought

FAULHABER has thus developed an entirely new, 2-pole, brushless 16-millimetre motor. The new BHx series demonstrates that a motor with this dimension can offer significantly more power than previous models. "We took a very fundamental approach to this question and revisited the physical principles of electromagnetic power generation with fresh minds," explains product manager Silvio Taraborrelli. "The basis of these principles is the so-called Lorentz force, which arises from the interaction of magnetic field and

BRUSHLESS DC-SERVOMOTORS

1660…BHx series
∅ 16 mm, length 60 mm
Output torque 16.8 mNm

flow of charge. This force is used in full when the wire of the coil is perpendicular to the magnetic field. With the traditional angled winding of the coils, part of the Lorentz force is lost which is why we developed a new winding technology. With this so-called segment winding, we can now optimally align a large part of the wire. As a result, we get much more power with the same diameter, same amount of copper and same power consumption."

The new motor is available in two versions to accommodate different requirements. The 1660…BHT model – HT standing for "high torque" – has been optimised with regard to the maximum continuous torque of 18.7 mNm, this version is also capable to deliver intermittent torque above 30 mNm for application requiring impulsive cycles. The 1660…BHS can achieves high-speed up to 100,000 revolutions per minute and is dedicated to applications where the motor is operating almost continuously or in handtools where the unit operates for extended period.

Load change and continuous operation

Besides these differing characteristics, the two variants of the motor offer similar benefits. These include, among other things, particularly quiet and practically vibration-free running, which facilitates handling the machine over a long period of time. Since a particularly large part of the energy used is converted into motion, heat dissipation is no problem either – the handpiece remains relatively cool for the most common application requirements. This is especially the case for intensive operation with short-term overload conditions. The rugged, micromotors can easily handle both continuous or intermittent use scenarios, while they can process highly dynamic movement patterns at the same time.

The extremely flat speed-torque curve down to 95 rpm/mNm allows a very high motor performance, easy control and helps to avoid large speed drops under variable load conditions.

One of the strengths of the new motor series is also the precisely adapted electronics. They are equipped as standard with digital Hall sensors and can therefore also be operated without an encoder. If this does not suffice, the motor can be combined with high-resolution incremental magnetic encoders.

Pre-loaded ball bearings ensure that the motors can easily withstand the radial and axial forces that the handpiece is subjected to. They are designed for an extremely long service life. The motor can work without and with gearhead. In the first case, numerous matching precision gearheads are available. Product manager Silvio Taraborrelli is convinced: "This motor relieves the hand holding the machine. This then offers more freedom for highly precise work."

RELAXING CHAOS

Leaves rustling in the wind, clouds floating across the sky, waves rolling up and down. Evolution developed the human eye to notice this constant change in nature. The constant movement – unpredictable in its details and "chaotic" in the most beautiful sense – is apparently good for the soul. Why else would a fireplace fire or an aquarium have such a relaxing effect? The kinetic sculptures of Bert Schoeren also follow the principle of chaotic movement.

When the Dutch artist presents his works in museums, they are sooner or later surrounded by chairs: "I never mention it, but the exhibitors quickly realise that the furniture is needed", explains the trained engineer for industrial design. "The visitors want to linger and watch the objects dance." Not only does nature serve as Schoeren's source of inspiration, but also as the operating power for his sculptures. If they are located outside, it is usually water and wind. Indoors, he prefers to use sunshine, as is the case in the solar mobile "Network".

It hangs in the training centre of the Dutch energy company Alliander in Duiven. Ideal conditions can be found for his solar sculptures in the glass foyer: plenty of space and daylight. Fittingly, the building is also an active energy house, which produces more energy

Bert Schoeren

than it consumes. "I've found that technically oriented people enjoy such works of art a great deal", explains the likewise technically inclined artist. "What's more, by definition the solar mobiles emphasise the aspect of sustainability, which plays an increasing role in more and more companies."

The mobile consists of 135 coloured plates with solar elements and small propellers, i.e., producers and consumers of energy, as the artist explains. Whenever the sun shines in the foyer, the small panels begin to produce electricity, each a different amount, as they are positioned at different angles to the incident sunlight. The collected solar energy is stored in small batteries. As soon as a battery is charged, the propeller begins to turn for a short time, moving an arm of the mobile in gentle chaotic circles. With each movement, the work of art forms a new, unpredictable structure, enlivening the room and its atmosphere.

The power of the sun is greatly reduced in a building, even with the largest glass façade. Of 100,000 lux outdoors, no more than 2,000 lux reaches the indoors. Thus, the power supply of the small panels is anything but lavish. To make optimum use of the limited energy, Bert Schoeren therefore set out to find the most efficient micromotor. He tried a number of different models. After testing, he found a clear winner: DC-micromotor 1224…SR with a diameter of 12 millimetres. This motor transforms the attenuated energy of the sun rays into mechanical power sufficient to produce the meditative and stress-reducing motion of the mobile.

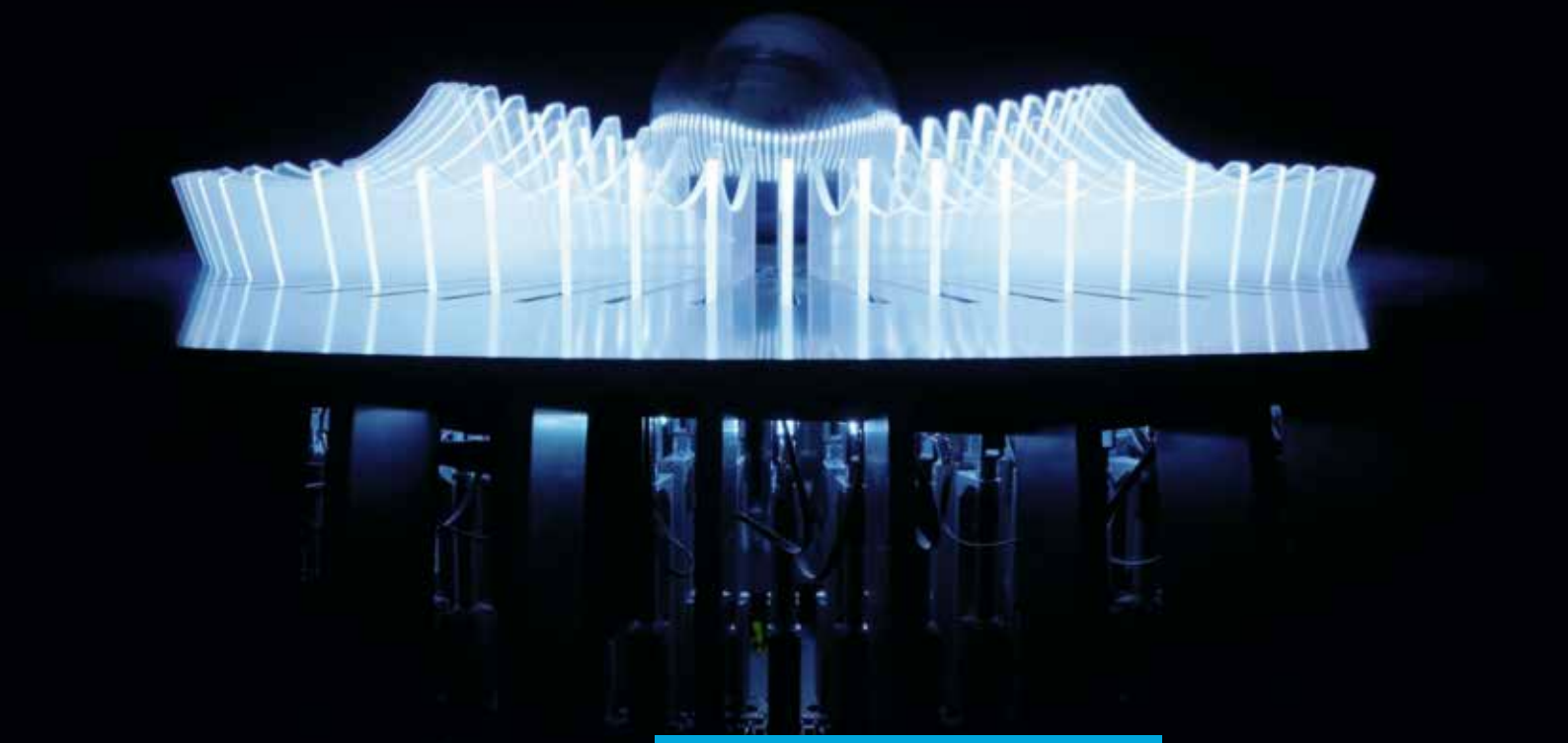
DC-MICROMOTOR

1224 … SR series
Ø 12 mm, length 24 mm
Output torque 1.7 mNm

FURTHER INFORMATION

BERT SCHOEREN · KINETIC SCULPTURES
www.schoeren.nl

FAULHABER
www.faulhaber.com



CHOREOGRAPHY

IS ALWAYS A QUESTION OF PRECISION

Flowing, living movement without cogging torques, a strictly linear force-current ratio, high dynamics, exact position control: thanks to these properties, the linear DC-servomotors from FAULHABER are ideal for micropositioning tasks – or for bringing a fascinating work of art to life. The kinetic sculpture "Project Anthozoa" – a collaboration between MKT AG, flying saucer GmbH and FAULHABER. Learn more in the next FAULHABER motion.

MKTAG Fine Exhibition Engineering

flyingsaucer ATTRACTION DESIGN & ENGINEERING

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