Dräger Review 97.1

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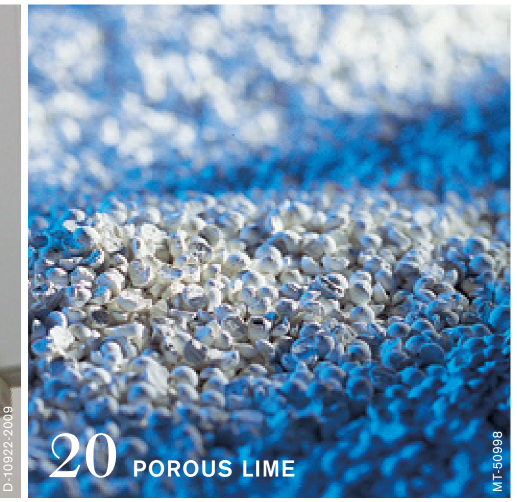
Gentle Care

External stimuli influence the development of preterm babies

Around **7,000 m^2**—that's the internal surface area of the soda lime developed and manufactured by Dräger in one CLIC disposable absorber. Read more on page 20.

COVER PHOTO: MT-41-2002

MT-58-2002



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What Moves Us—Dräger Worldwide

Janine and Jörn Stührenberg and their six children, Bremen, Germany

"We're waiting for our quad baby stroller right now. Until it comes, I've been putting our lightest baby in a sling, while three ride in a twin stroller. It's cozy, but soon it'll be too small. Living with quadruplets means you have to improvise. Unfortunately, a lot of people just aren't into improvising as much as our family is. Many stores have discounts for twins, but just try to turn that into a discount for quadruplets! For baby swimming, you need one adult per child – but there are always only two parents, even for quadruplets. Despite all these obstacles, we make do quite well, and that goes for our two older children too. The quadruplets were born in the 30th week of pregnancy, ten weeks early. The team working with Dr. Thorsten Körner at the 'Klinikum Links der Weser' was prepared for anything. The delivery room was almost as busy as a train station: there were physicians, an anesthesiologist, midwives and pediatric nurses, and – somewhere in the middle of the crowd – my husband. After the birth, I had to get used to the technology. You think that you'd actually like to care for the children yourself. But of course they need incubators and equipment to help with breathing. They were given little masks, and I learned to understand everything pretty quickly. Before long, I could intuitively tell from the sounds whether the blood oxygen level or the pulse was falling. Everything worked reliably; the children progressed well and no longer needed the equipment. We made it home by what was originally supposed to be the due date.

I found it comfortable in the hospital. Staff members often came to me and said: 'Oh, we're sorry, we're giving you so little attention with your children'—there was one emergency after the other coming in. And I was glad they just hurried past, because that meant everything was OK."

PHOTOGRAPHY: JASMIN LINDENTHAL (LEFT), ULRIKE SCHACHT (RIGHT); TEXT: SILKE UMBACH

Björn and Sven Guericke, Technisches Hilfswerk (THW), Itzehoe, Germany

"We sit on packed trunks, so that we can set off in six hours. Our destination is somewhere where something has happened and people urgently need help—especially clean drinking water. Whether it's the result of an earthquake or flooding, there's always a shortage of drinking water. Drinking polluted water can be fatal, particularly for children. It kills more people every year than malaria. But we can help. One of the places where the THW has stockpiled specialized equipment is in Itzehoe, in north central Germany. Here there are portable processing machines that we can use to filter and sterilize large quantities of water.

We work in China, India, Indonesia and Africa. Maybe we've become closest to the people in Uganda. Especially the children in a refugee camp, who went to school every day despite the terrible conditions after the floods in the fall of 2007. About 40 of us helped out, and we supplied 3,500 people with water. During the kids' long break, we waited for them at the fresh water tap, and pretty soon we organized soccer games. The people made a big impression on us and knew how to achieve so much with the most basic resources. That's why we traveled there again in a private capacity and founded the Oongora Partnership Project, which has already donated school uniforms and a power generator. At the start of a THW career, you're fascinated by the technology. Then the ability to provide assistance takes over: We see how much we accomplish. And if something happens tomorrow? No problem, we'll deal with it." The THW is equipped with Dräger technology: from helmets to respiratory devices and gas measurement equipment.

Research to help the littlest ones.

German Neonatal Network Launched

The German Neonatal Network (GNN) went into operation at the Lübeck campus of the Universitätsklinikum Schleswig-Holstein (Schleswig-Holstein University Hospital) at the beginning of 2009. The research network, which currently includes 35 clinics across Germany, has received 2.5 million euros in funding from the country's Ministry of Education and Research.

The GNN will examine the data of 20,000 children over the next six years in order to identify factors that have a favorable effect on the long-term development of very small premature babies. The study is being directed by Professor Wolfgang Göpel, a neonatologist and pediatric intensive medicine specialist at Lübeck Children's and Youth Hospital. The research will focus on the therapeutic measures commonly employed with premature babies and the significance of sociological and genetic factors.

Göpel expects the study to identify genetic and clinical factors that play a role in the development of typical illnesses associated with premature births.

Ensuring no one gets burned when it gets hot: Realistic exercises in the fire area.

The Heat is on in Chongqing: Realistic Firefighting Drills

With a population of over 30 million, the Chongqing administrative district in central China is said to be the largest city in the world. Its many residents can now also sleep easier, thanks to a new training center and concept that the Chongqing Fire Brigade recently obtained from Dräger. The center, developed on the basis of globally recognized European standards, provides fire brigade staff with realistic training in firefighting and rescue techniques, as well as instruction in the proper response to terrorist attacks.

At the center of the training site is a ten-story building, the first floor of which contains two classrooms and a control center from which the entire facility is monitored via infrared cameras. The second floor houses a labyrinth style maze that can be flooded with training smoke and coupled with realistic noise simulations of various operational events. The building is also connected to a tower where training course participants can practice rescue operations at great heights, including exercises with turntable ladders. Two fire areas form the centerpiece of the training center. These gas-fired chambers are set up like an apartment, which enables realistic training enviroments such as kitchen fires (including grease explosions) to be realistically simulated under computer control.

An additional scenario has a blaze in a bedroom, including a burning bed, and there are also realistic exercises for battling backdrafts. The training center was designed and developed in cooperation with architects from the local fire department. "The training center in Chongqing offers the kind of state-of-the-art technology that firefighters the world over have come to expect," says Mat Lock, Regional Manager Dräger Safety Solutions—Asia Pacific.

Cold outside, comfortable inside.

Measuring Core Body Temperature in Space

On February 11, 2009, the European Space Agency (ESA) launched a rocket from Baikonur (Kazakhstan) on a journey to the International Space Station (ISS). On board was as well a new type of Dräger sensor. Initial studies carried out prior to the trip that this sensor can reliably measure human core body temperature without the need for an invasive procedure. Further studies have also shown that the results of this technique are so reliable that it can be used in lieu of invasive measurements that have been commonly employed in the past – such as those taken in the esophagus.

The sensor is also being used in the space mission to transmit vital data to determine the physiological stress experienced by the astronauts. This configuration is now being tested for various applications, including for use in a future manned mission to Mars.

Ponta combines form and function.

Award-winning Design

Each year, Industrieforum Design in Hanover, Germany, evaluates various products for their unity of form and function. In 2009, less than one third of the products submitted for consideration received an iF Product Design Award, among them two Dräger products developed in accordance with the company's latest design guidelines. These winners, which received awards in the "Medicine/Health+Care" category, were the ceiling-mounted Ponta beam system supply unit and the Infinity C700 workstation. Ponta integrates outlets for gas, electricity and IT connections, as well as dimmable light sources. The infinity C700 is a medical-grade workstation that integrates vital signs and networked clinical information. Both designs are the result of cooperation between international Dräger teams and the Corpus-C design agency. These awards make clear the exemplary character of the products' color and shape, as well as their environmental friendliness and degree of innovation.

Dräger Helps to Bring Cell Phones to Operating Rooms

Wireless communication is highly efficient. Until recently, however, the benefits of cell phones, WLAN etc. could not be enjoyed in hospital care areas because the electromagnetic waves they emit can interfere with the functioning of medical equipment. The IEC60601-1-2 standard stipulates that – to ensure the greatest possible safety – there must be a distance of at least 3.30 meters between medical and electronic communication devices.

"This is purely a precautionary value that's used because the standard for shorter distances does not call for suitable testing methods," says physicist Gerd Matzke, who helped develop a new testing procedure for Dräger that dramatically reduces the so-called protective distance. "The results to date show that Dräger medical equipment can be safely operated at just two foot-lengths from all common wireless units."

Matzke and his team achieved this breakthrough by developing a small special antenna that enables an electromagnetic field to be brought very close to sensitive components in medical and safety equipment. "Through extensive tests with Dräger products, we determined that the previous safe distance of 3.30 meters can be substantially reduced—in some cases even down to zero," says Matzke, whose testing procedures yield reproducible measurements for achieving significantly lower safe distances, and could thus serve as the basis for a new standard. "Any device that successfully passes our test can be safely operated at a distance of at least 60 centimeters from a wireless communication device, if not closer," Matzke reports.

The new testing procedure can thus for the first time help expand the use of patient monitoring devices, for example, and probably enable the utilization of many wireless applications in the vicinity of sensitive electronic equipment.

Quiet, Please: We're Still Growing!

The effect of external stimuli on **PRETERM INFANTS** is a relatively new field of research, and it has already led to significant changes in the ways such infants are cared for.

The number of infants who are born prematurely in the U.S. has almost doubled in the past decade.

THE DEVELOPMENT of neonatal care for these "preemies" is already a success story, and there's no end in sight. The great progress made in neonatology in recent decades, thanks to new medications and innovative technology, has enabled clinics to deal with many medical problems, increasing the odds that a preterm infant will survive dramatically.

For many decades, the number of infants born in the U.S. before the end of the 37th week of pregnancy had held steady at seven percent. But in the last 10 years neonatologists have observed an increase in the frequency of premature births, to approximately 12 to 13 percent of all pregnancies. In particular, the number of very small preterm infants (those weighing less than 1,000 grams) has increased from 0.7 percent to approximately 1 percent of all newborns (Epidemiology and causes of preterm birth; Goldenberg RL, Culhane JF, Iams JD, Romero R.; The Lancet 2008 Jan 5; 371(9606):75–84). "In the area of neonatology we're seeing an increase in the number of smaller preterm infants," says Prof. Johannes Pöschl, Medical Director of the Clinic for Neonatology in Heidelberg, Germany. "The causes include pregnancies late in life, an increase in the stressors affecting the mothers, and developments in reproductive medicine."

Stimuli disturb development

Premature birth can mean that a tiny infant leaves the protection of the uterus as many as 16 weeks before the normal birth date. At that age the infant's brain is still largely smooth—a tabula rasa, in effect. A significant phase of its brain development has just begun. The stimuli to which it is now exposed are completely different from those it experienced while still inside its mother's body. Many of the stimuli are not pleasant, and some can even disturb the infant's maturation process. "Today it's no longer merely a question of the infant surviving by every medically possible means," says Sabina Bitter, the pediatric nurse who heads the neonatology ward at the University Clinic in Essen. "We want the preterm infants to develop optimally, not only at the motoric but also at the neurological level. Twenty years ago people were less concerned about negative stimuli such as too much noise or glaring lights. We would cover the incubators with towels to shield the newborns a little. From the early 1990s on, newborns were cared for in line with the concept of 'gentle care.' The focus was on minimal handling and infant care in accordance with kinesthetic criteria. The infants were provided with small positioning cushions that provided boundaries. But for about the past three years we've been seeing great changes in the direction of family-centered care that promotes child development. This process started when we >

ABSTRACT Twelve to thirteen percent of all babies in the U.S. are born before their calculated birthdate. These preterm infants require a special kind of care, because in many cases their brain development has only just begun. Disturbing external stimuli in the incubator can lead to deficits in the babies' later development. Special care concepts take these latest research results into account.

Caregivers learn the "preemie language" in the NIDCAP program

> began to care for our tiny patients according to the NIDCAP principle."

She's referring to the Newborn Individualized Developmental Care and Assessment Program, which Dr. Heidelise Als began to develop at the Children's Hospital in Boston, U.S., in the 1980s. Studies of brain development suggested that certain characteristics which frequently occurred in preterm infants as they grew older—attention deficit disorders, learning difficulties and weak self-regulation processes—are partly due to the overwhelming sensory input to which these infants' immature nervous systems had been subjected. Als' desire to structure these initial life experiences ex utero in a way that was more appropriate for preterm infants inspired her to develop the NIDCAP program.

Individual elements of this standardized observation program, which is known as "developmental care," are implemented in many ways in a multitude of clinics. The concept is not strictly defined, and as a result it can include all of the measures that promote the child's sense of well-being and take its needs into account when evaluating pleasant and unpleasant stimuli. For example, "kangarooing"—carrying the infant next to its parent's skin—is a normal practice today in neonatology units.

Intensive care medical personnel are also increasingly taking into account nontechnical factors in order to avoid causing negative stress to the infants. That means trying to minimize factors such as lighting conditions, noises inside and outside the incubator and painful procedures such as taking blood samples. "If the manual activities that the nurses perform during their rounds are carried out just when the child is in a rest phase, that too can cause stress," says Pöschl. Even though all preemies are similar in their need for conditions that resemble a mother's womb as closely as possible, each is also a tiny but very individualistic human being that grows, matures and changes its degree of sensitivity to stimuli. This is the point where NIDCAP as an individualized program sets in. The medical personnel who complete the training program in one of the 17 training centers in the U.S. and Europe learn something that could be called the "preemie language," because these infants communicate very differently from children born on schedule. The staff learn to interpret around 100 different signs of disorientation, stress, defense and withdrawal or, alternatively, organization, balance and well-being according to the "synactive theory" developed by Als.

Individual observations

This is what the program looks like in practice: "We observe the individual baby before, during and after our care procedures so that we can find out how it deals with different life situations," says Agneta Kleberg, a Master Trainer in NIDCAP techniques in Europe and at the NIDCAP Centers in Lund and Stockholm in Sweden. "We describe its individual behavior and the efforts it's making, and we make recommendations to the physicians, nurses and parents on how to interact with this particular baby. The most important things to watch for are the baby's breathing patterns, skin color and any changes it shows, its motoric system, and states of excitement and rest," adds Kleberg, who is a nurse and has a Ph.D. in patient care. In the ideal case, a child is observed once a week for an hour by a nurse trained in the NIDCAP program. In many cases, medical monitors are slower to register changes than well-trained observers. The trained nurses can sometimes detect signs of disturbance in a child's behavior long before there are measurable changes in heart frequency, breathing patterns or oxygen saturation.

This approach can potentially disrupt a ward's schedule if care procedures may be carried out only when the individual child is ready for them. However, because the program results in babies that are less stressed and are in a more stable physical condition, it requires fewer care procedures. The additional time spent on individual procedures thus results in time savings overall. "For nurses and nursing aides who are used to being experts in preterm infant care, there's been a paradigm shift to the view that they should regard the baby as an active, competent and sensitive partner and patient," says Kleberg. "Care personnel and physicians usually do their work in a task-oriented way. By contrast, we are trying to transform this 'adult perspective' into a relationship concept." Moreover, care personnel are not used to the fact that this approach also means doing everything possible to make the parents the child's primary caregivers. "The initial costs of switching to NIDCAP principles, in terms of time and money, are balanced out by shorter periods of rest in the incubator, less frequent need for artificial ventilation, fewer cases of brain hemorrhage, less frequent use of feeding tubes, fewer medical complications, and a better parent-child relationship over the long term." According to an article by Als in the Encyclopedia on Early Childhood Development, the results of this program in the U.S. vary, but they indicate savings potential of at least 4,000 US dollars per child.

The pros and cons of NIDCAP

Nonetheless, not every practitioner believes that the effectiveness of NIDCAP has been convincingly demonstrated. It's true that Kleberg et al. (Early Human Development 2002, 68, pp. 83–91) have shown that after one year, preterm infants cared for in line with the NIDCAP program registered better cognitive development according to the Bayley Scale of Infant Development than preemies in a comparison group. However, the authors point out that the number of infants in the sample was very small and that there had also been a certain amount of spillover, because the nurses in the comparison group also tried to care for "their" infants in ways that would promote their development. "It's difficult to demonstrate the advantages of this kind of development-promoting care in a way that is statistically significant," says Pöschl. "In the few studies we have in this area, there is often only a small number of infants in the sample. These studies show that the patients develop in very diverse ways. The advantages of the NIDCAP program have not yet been directly proved, but it seems that there is better motoric and mental development in the preterm infants that receive this kind of care."

In the intensive care stations for new- >

Better growth with positioning aids

Positioning aids can help nursing staff avoid putting infants into negative positions in an incubator. In other words, these aids are not simply a way to make babies more comfortable—they are a medical necessity. The positioning of the baby can have a huge influence on its growth and development. Many preterm infants do not yet have enough strength to hold their arms and legs steady. Changing their position regularly in the incubator prevents them from lying in negative positions and promotes their further development. Dräger has developed a positioning cushion called "Nestchen" (Little Nest) that is specially shaped for "gentle care" requirements, and a positioning aid called "Hug it" that stabilizes the entire body of a baby weighing up to 1,500 grams.

Special positioning aids in the incubator can prevent negative positioning of the baby.

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A little bit of stress can help promote development

Preterm infants need a special dose of attention.

> borns in Sweden, it has long been standard procedure to ensure that about five percent of the staff have received a NIDCAP qualification. "The cost of this training, not including the loss of working time, is about 6,000 euros per trainee up to the first certificate, which takes about a year," says Kleberg. Other countries in Europe have a scattering of NIDCAP centres. This year, Heidelberg will become the first NIDCAP application centre in Germany. It already offers much lower-cost training courses in a program it has created itself called EFIB—the Germany acronym for "development-promoting, family-centered individual care." The EFIB approach is based on the conclusions reached by NIDCAP, the guiding principles of the German Federal Association for Preterm Infants and the Heidelberg Curriculum Medicinale. "Our approach to the care we provide to these children is based on NIDCAP. We've modified the assessment program to fit our needs and adopted the NIDCAP observation sheets with the approval of Heidelise Als as the creator of NIDCAP," says Pöschl.

From a hushed underwater world

A further objective of the program is to enhance parenting skills. The primary focus of the care concept itself is to interfere with the infant's brain development as little as possible. For infants born after a pregnancy of less than 33 weeks, there is still a great risk that the child will later develop partial vitality deficiencies. This was shown in the EPIPAGE survey published last May in The Lancet (Vol. 371, No. 9615, pp. 813–820). Common sense tells us that delicate creatures like these—a mere handful of humanity—should be treated gently. It also sounds logical that we should reduce negative stimuli such as noise, light and pain and promote positive ones such as skin contact and the sound of a parent's voice.

Infants require a small amount of eustress (beneficial stress) in order to develop properly. In other words, their surroundings should not be too dark or too quiet, because that's not how it is in the womb either. The friendly orange glow shining through its mother's abdominal wall, which turns lighter or darker depending on the time of day, is perceived by the tiny infant as a series of grey shadows—color perception becomes differentiated only at a later stage. The noise level decreases to a minimum of around 28 decibels. But if the mother, for example, loudly cheers on her favorite soccer team, her shouts vibrate through the uterus at a volume of over 83 decibels. However, even that is 25 decibels softer than the sound of a plastic milk bottle being set down on top of the incubator. For an infant coming from a hushed underwater world, not only the absolute noise level but also the unaccustomed frequencies of the noise cause stress. It's much more difficult for preterm infants to settle down, fall asleep or attain a state of attentive wakefulness. The top priority of human beings and technology should therefore be to reduce the level of disturbing noise whenever possible.

In a comparative study of the noise levels at three incubators (Effect of Environmental Changes on Noise in the NICU, Neonatal Network Vol. 26, No. 4, 2007), the Dräger Caleo was judged to be the friendliest acoustically. "The Caleo, which registers less than 47 decibels in its interior, is very quiet," confirms Silke Bahr, Product Manager at the Neonatal Care & Thermoregulation unit at Dräger. "The routine noise in some intensive care stations could be a bigger problem than the incubator." The sensitivity of the tiny patients should not be underestimated. Until a few decades ago, it was widely believed that because of their physiological immaturity premature babies could not feel stress or pain, but today we know that even an overly loud laugh can disturb a tiny infant.

"We actually have three sets of customers whose wishes we need to take into account simultaneously: the medical personnel, the small patients and their parents," says Bahr. Previously, innovations in medical technology were the primary focus, but today people in this field are thinking more intensely about parallel issues: how to ideally promote the child's growth and good health, how to ease the interaction between parent and child and, above all, how to satisfy the child's desire for a sense of well-being. For example, x-ray examinations are a necessary medical measure that can be carried out in a very gentle way. Is there an integrated drawer into the incubator, the preterm infant can be x-rayed without having to be moved.

A closer relationship

"As product developers we continually ask ourselves to what extent we can support the concept of development-promoting care through our designs for basic medical equipment and accessories," says Stefanie Wagner, Product Manager in the Lifecycle Solutions unit at Dräger. "With regard to our positioning aids, this means that we have to reproduce the infant's position in utero as closely as possible. We therefore create the physical limits that the preterm infant is used to, and within this environment it can be comfortably positioned so that it can bring its hand to its mouth, brace its feet against something and snuggle down into its nest." Appropriate covers for the incubators dampen light and noise, and the friendly rounded shapes of the Caleo plus the colorful textiles used transform a sober incubator into a cozy child's room in miniature. The appearance of the Caleo should also make it easier for parents to realize that their child is well cared for in its temporary "home" without being overly distracted by the surrounding technology.

Everything that promotes early bonding between parent and child benefits the child's development over the long term. For example, a study by Agneta Kleberg (Early Human Development 2007, 83, pp. 403–411) showed that mothers who had spent a lot of time with their preterm infants—as is usual in the NIDCAP centers—felt a closer bond with their children after 36 months than mothers whose children were cared for traditionally. "Of course, the better results achieved in language tests by toddlers cared for in NIDCAP programs could simply be due to increased parent-child interaction," Kleberg admits. After all, in order to grow up healthy, children need not only calm and security but also lots of attention and physical closeness. **Dr. Sabine Wienand**

Further information online:
Interview with Silke Mader, Chairwoman of EFCNI
www.draeger.com/97/neonatal

Instant detection of jaundice

Newborn jaundice is a potential risk for babies. It needs to be detected at the earliest possible stage in order to prevent later harm to the child. The bilirubin measuring system JM-103 Jaundice Meter determines the key element of the diagnosis—the baby's total bilirubin concentration—in a noninvasive manner. The measuring head is simply held against the infant's forehead or breastbone, and the bilirubin value can be immediately read.

Focusing on the Essentials

In a hospital environment the purpose of technology is to help healthcare providers perform their daily jobs. One example of that is the **EVITA INFINITY V500** ventilation component at the University Medical Center Hamburg-Eppendorf.

The University Medical Center Hamburg-Eppendorf: one of the most modern of its kind in Europe.

Patient information: hemodynamic and therapeutic data must be readable at a glance in the intensive care unit.

GREEN FOR ECG, red for blood pressure, and blue for blood oxygenation: The patient monitor in the intensive care unit of the University Medical Center Hamburg-Eppendorf (UKE) shows an array of vital data. Dr. Stefan Kluge, acting head of Intensive Care Medicine, takes a quick look at the display. This gives him a rapid overview of the patient's current situation, along with the ventilation parameters displayed on the screen of the Infinity Medical Cockpit, which stands alongside.

The latter shows how the new ventilation component of the Infinity Acute Care System—the Dräger Evita Infinity V500—is interacting with the patient's lungs. Together with 19 other devices, this is the latest addition to the system and one of the most modern pieces of therapeutic technology in what the hospital administration proudly refers to one of the most modern university medical center in Europe.

The relocation challenge

During the last weekend in January 2009 the UKE relocated from its old premises—172 historic pavilion buildings—to a brand-new multistory building with 3,500 rooms. Altogether, the move involved 17 clinics, including all patients, personnel, and medical equipment. In the process Kluge and his team transported a total of 37 intensive care patients, some of them critical cases requiring mechanical ventilation, continuous monitoring, or dialysis. The whole procedure required three times as many medical teams as during normal service.

The primary reason for the relocation was integration—a key topic in modern healthcare. Integration covers not only the areas of hospital administration and logistics but also the full range of medical technologies that are required to meet today's very highest standards of patient care. Now, it's not every day that a large clinic moves to new premises. Yet every day of the year in hospitals throughout Germany, patients are moved, including patients in intensive care, with all their special requirements—fluid management, ventilation, and monitoring.

Wherever patients are transported, this can have a serious impact on workflow, involving a loss of data or, even worse, a crucial delay in recognizing a deterioration in a patient's condition. For this reason, an increase in integration, interaction, and synergy between the various medical systems in use has the potential to save lives.

That is exactly the aim of the new technology, and the UKE is helping to perfect this process. "We're seeing very clear progress here," confirms Dr. Kluge. "The individual machines interact as a complete system, and that gives us perfect integration between ventilation and monitoring. The data thus generated can then be fed straight into an electronic patient file without the need for any further processing.

"The Dräger Evita Infinity V500 is very good for non-invasive mask ventilation, which we'd like to use much more instead of invasive tube ventilation," adds Dr. Kluge. "And when it's equipped with the SmartCare/PS option, which we have with 10 of our ventilators, it also interacts with patients during the weaning process and helps guide them gradually back to independent breathing."

Seamless integration

Interaction and communication are the two key concepts in this trend toward comprehensive integration in the clinical setting. While data needs to be maintained, updated, and made available, developers are also increasingly focussed on improving the user interface. "In the past, hospital personnel have been expected to carry an increasing workload. It's therefore all the more important that we can once again concentrate on our key areas of responsibility," Kluge explains. "And that means doctors should focus on treating patients, and caregivers on providing care."

This is facilitated not only by enhanced user interfaces but also by the fact that the new ventilation components are equipped with intelligent safety features. These include RFID chips, which communicate via radio with the system and trigger an alarm if a ventilation tube >

ABSTRACT The ongoing integration of medical and information technology provides doctors, caregivers, and hospital administrators with greater room for maneuver. Similar to an aircraft, the Evita Infinity V500 from Dräger, consolidates all the relevant data in a "cockpit" and gives doctors a free hand to intervene as appropriate.

As in an aircraft cockpit, all the key data is intelligently consolidated

> has been wrongly connected or remind caregivers when a particular accessory has to be replaced. And the fact that the entire initial ventilation configuration can be stored on a USB storage device also makes life a whole lot easier. This not only makes it much quicker to configure another ventilator but also eliminates the possibility of any errors in manual configuration at this interface. “These basic concepts can be applied in any context where doctors and technology interact,” explains Dr. Kluge.

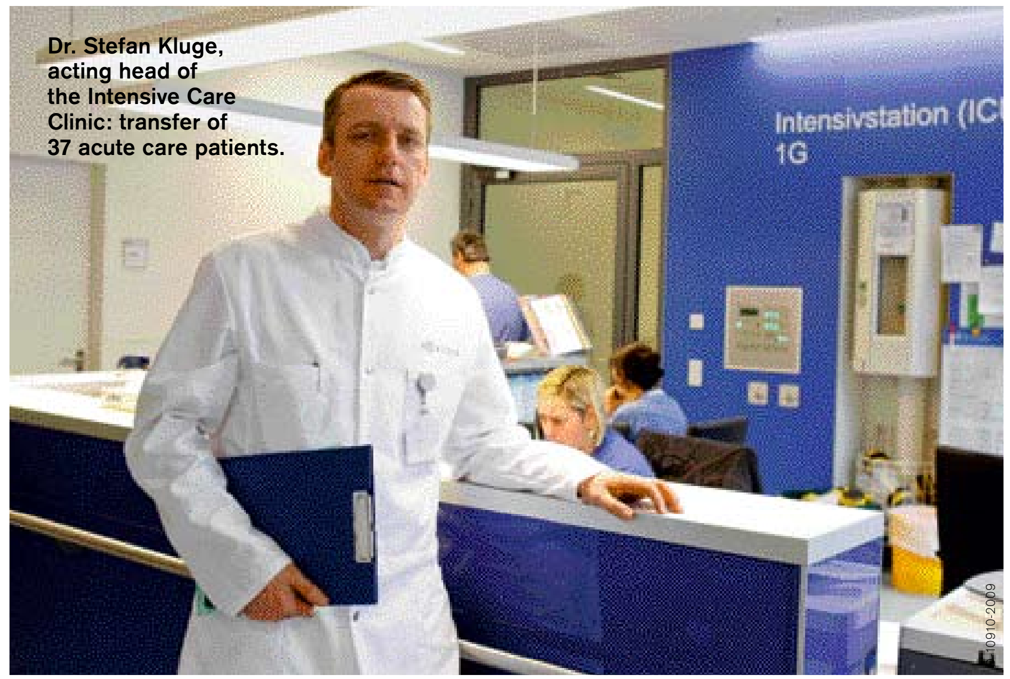
Five seconds

Prof. Alwin E. Goetz, Director of the Department of Anesthesiology at University Medical Center Hamburg-Eppendorf, likes to draw on examples from the world of aviation to describe the paradigm shift that has taken place in medical technology (see Interview, page 17). As he insists, there is no question of using robots or other machinery to replace doctors at the bedside. Like a pilot, the physician in the intensive care unit retains full control over the therapeutic instruments at his or her disposal. As in the cockpit, however, at the bedside of an intensive care patient it’s vital that all the relevant data is intelligently consolidated and presented according to the precise clinical situation. And that means separating the relevant information from the redundant data that would otherwise hinder the decision-making process.

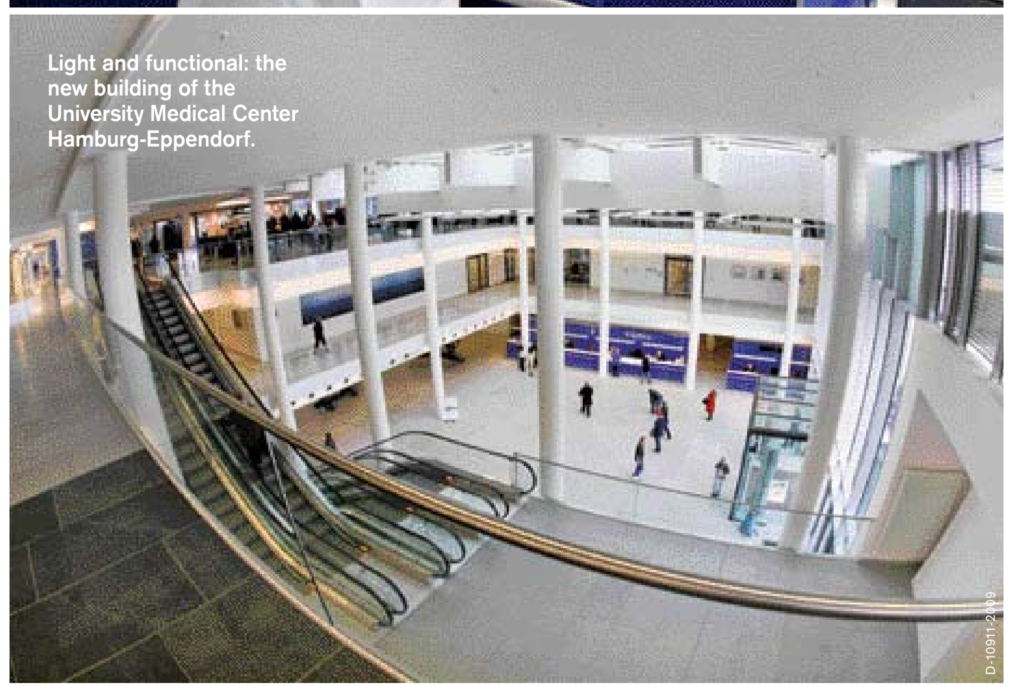
The doctor retains the freedom to add his own individual preferences to the “doctor-machine interface” via the touchscreen and various interaction settings, for example. This configuration can then be saved in exactly the same way that a pilot can change the scale and the complexity of the information displayed on the cockpit instruments according to the current requirements and workload. And just like piloting a state-of-the-art aircraft, the practice of intensive care medicine is all about enhancing standardization and eliminating incompatible interfaces and time-consuming searching for the right solution. All this helps minimize risks and free up resources.

Yet the UKE is not the only hospital where the new Evita Infinity V500, as a component of the Infinity Acute Care System, is already answering the call for comprehensive integration in the clinical setting. Indeed, the new ventilation component is also proving its worth in Heidelberg, Magdeburg, and Zurich. What’s more, this approach is set to spread, because it so patently meets the needs of a healthcare system that is going to be treating more and more complex cases, introducing increasingly structured processes, and continuously enhancing its knowledge management.

In the middle of explaining all this, Dr. Kluge is suddenly interrupted by an acoustic signal coming from the patient monitor: The patient’s blood pressure has exceeded a preset limit. Following five seconds of the doctor’s undivided attention and a quick, experienced scrutiny of the display, our conversation continues. The system has everything under control. **Silke Umbach**



Dr. Stefan Kluge, acting head of the Intensive Care Clinic: transfer of 37 acute care patients.


Light and functional: the new building of the University Medical Center Hamburg-Eppendorf.

“We’re in a cockpit situation”

PROF. ALWIN E. GOETZ is Director of the Clinic and Polyclinic for Anesthesiology and Medical Head of the Center for Anesthesiology and Intensive Medicine at the University Medical Center Hamburg-Eppendorf. He believes that the increasing computerization of medical technology is set to play a crucial role in the future of healthcare. Here he discusses the medical and economic aspects of this approach.

Professor Goetz, you’ve long been involved with technological advances in anesthesiology and intensive care. What have been the landmark moments?
In the past it was common wisdom that a university medical center should have a large range of equipment, so as to give doctors the chance to get to know all the systems in use, and adapt their experience to the medical requirements. Today, however, funds are limited, and the key factor is an increasing computerization of medical equipment. We’re now in what you might call a cockpit situation: thanks to computers we can monitor a continuous loop of diagnosis and therapy.

Stretching from admission to discharge?
That’s right. As soon as a patient is admitted to the emergency room, the essential parameters get monitored. This monitoring stays with the patient, all the way through trauma room, radiological diagnosis, anesthetic, operating room, and so on. That gives us a nonstop feed of vital diagnostic and therapeutic data. And most important of all, nothing gets lost during transfer to other departments.

Is a greater degree of system integration possible?
Definitely. A system that uniformly integrates all the various components such as monitoring, ventilation, and volume/cardiovascular therapy also enables greater automation of the combination of diagnosis and therapy. The ventilation system generates a stimulus, the patient reacts, and the monitoring system provides feedback. The physician monitors and receives advisory and early diagnostic and therapeutic notifications. That generates enormous savings on training. With the old system, there was a host of different technical platforms, which meant you needed months to get acquainted with all the technology. At the same time, the old system undoubtedly led to safety issues, as data was repeatedly getting lost between the different processes. You also had to constantly readjust. There’s a very good reason why airline pilots only fly an A320, for example, and not a different aircraft every other day. The airlines have learnt that the pilot and aircraft adapt to one another, and they know the importance of systems integration.

What do such advances mean for the development of new technologies?
We have a genuine cooperation agreement with Dräger—we contribute our experience. If we like something, we get behind this development. If not, as clinicians we also have ideas about how it might be improved. The demand placed on developers is really the same as that on the technology itself: integration. In the past, there were specialists working in their own specialist fields; today, they all have to cooperate and coordinate their development work with one another.

Will the trend toward greater integration prevail throughout the healthcare system?
It’s normal that cutting-edge technology first gets used in hospitals providing the very highest levels of care. We conduct very complex surgical procedures here and treat a lot of difficult cases, so we’re certainly right at the forefront of the field. At the end of the day, however, everyone will benefit from this gain in knowledge.

Navigating through Anesthesia

A pilot needs to know not only the plane's current position but also whether it is on a collision course with a dangerous obstruction ahead. Anesthesiologists are faced with a similar task when monitoring patients during an operation, which is why Dräger has developed an **INTELLIGENT DISPLAY** that is based on the idea of the moving maps used in aircraft navigation.

INFORMATION TECHNOLOGY has become part of the very fabric of modern life. It enables us to store huge amounts of data, for example, and to stay in touch at any time and any place. Many people can still vividly remember their first text message. For the anesthesiologist and scientist PD Dr. Thomas Bouillon, it was the encounter with digital navigation systems in the late 1990s that left an abiding impression. Dr. Bouillon had just started a fellowship at the University of Stanford in California, and was taking advantage of the sunny climate to train for his pilot's license. "It was my first experience of moving maps," he recalls. "Back then, they were just being introduced into aircraft cockpits."

A lesson from the cockpit

Obviously, moving maps are a great help when it comes to navigation—just think of GPS applications. In addition, they also enhance safety. For a pilot, it is crucial to not only know the plane's present position; he or she must also ensure that the aircraft isn't on a collision course with a dangerous obstruction ahead. The pilots do this by projecting the aircraft's coordinates—obtained from the GPS—onto a topographic chart showing the aircraft in its surroundings. The limits of high mountains or closed airspace appear so early in the display that the pilot has ample time to react.

Thomas Bouillon was perhaps not the first flying anesthesiologist to recognize the potential of moving maps for the operating room. For him, the similarities are obvious: after all, isn't it the anesthesiologist's job to pilot a patient safely through anesthesia? Indisputable, however, is the fact that he was one of the very first anesthesiologists to do something about exploiting the potential of this technology for the benefit of his profession. "The aim," he explains, "was to develop a real-time visualization of the actual state of anesthesia that would help the anesthesiologist in the operating room to administer the correct dosage of drugs without the need for any in-depth understanding of pharmacokinetics or pharmacodynamics."

In the fall of this year Dräger is set to introduce such an intelligent display to the market, which will be launched under the name of SmartPilot View. Dr. Bouillon, who today works as a senior expert in the Modelling and Simulation department at the pharmaceuticals company Novartis in Basel, Switzerland, is one of numerous scientists, engineers, doctors and managers who have contributed toward the development of this high-tech device.

The key question at the start of the development work was how to describe the real-time state of anesthesia in such a way that it could be captured and mapped on a two-dimensional graph. The problem is that during anesthesia, a variety of hypnotics and opioids are used. These are administered either intravenously or as a gas; their effects last for different lengths of time. Most importantly, they have an influence on one another. Some drugs reinforce, while others diminish, the effect of other drugs. Despite such complexity, developers were able to devise a model that graphically shows the interaction between hypnotics and opioids during anesthesia. This was the first step toward the creation of an anesthesia map. The x-axis shows the concentration of opioids, the y-axis the concentration of hypnotics. The current level of anesthesia is represented on this graph as a point of light that moves within the graph. Taking into account parameters such as age, weight, and gender, a change in the opioid concentration is represented by a movement of this point of light along the y-axis, and a change in the hypnotics concentration by a movement along the x-axis. As the operation comes to an end, the anesthesiologist must alter the dosage of drugs in such a way that the patient wakes up and experiences as little pain as possible. In the process, the point of light sinks to zero on the x-axis. In other words, the concentration of soporifics has been reduced, while the analgesics are still preventing the patient from feeling pain.

Remaining within the isoboles

The next step was to mark out the danger areas on the graph. These indicate the maximum and minimum concentrations of anesthetic agents and must be avoided during anesthesia. They show, for example, where the patient might regain consciousness although surgery is still in progress, or where the anesthetic becomes so deep that it would protract the wakeup phase beyond a reasonable length of time.

Based on the example of a moving map, the developers of the SmartPilot introduced a number of boundary lines (so-called isoboles) into the graph. The upper isobole marks a statistically determined state in which 90 percent of all patients show no reaction, whether in the form of perspiration, increased blood pressure, or an increased pulse, to the irritation caused by a laryngoscopy. As a rule, it therefore makes little sense to increase the concentration of anesthetic agents at this point. The lower isobole marks a state in which only half of all average patients do not react when spoken to or shaken. Assuming that the patient is to remain unconscious, it might therefore be prudent at this juncture to increase the concentrations of anesthetic agents.

What works fine in theory has now been confirmed by initial practical tests with the SmartPilot. Experts were particularly impressed with the operability and the quality of visualization of the solution, which Dräger will integrate into its Infinity Explorer software platform. "The display is highly intuitive to use and doesn't overtax the anesthesiologist in any way during an operation," says PD Dr. Martin Luginbühl, senior physician in the Department of Anesthesiology at Bern University Hospital, Switzerland.

Full overview

The display shows the data the anesthesiologist needs in three clearly structured columns. On the left is a 2D graph marked with isoboles, below the event markers. The middle column shows important vital parameters of the patient and data related to medication and the concentration of active agents. On the right is various information, including a prognosis of how concentrations of anesthetic agents and effective ingredients will develop over time. A glance at the display provides the anesthesiologist with information on a host of parameters and their development.

"Ideally suited"

The display features not only a graph showing the real-time state of anesthesia but also a variety of other data presented in easily comprehensible form. This includes the current concentration of each administered drug, represented in a different color. In addition, the anesthesiologist can mark different points in time on the display during the course of the operation. These might include, for example, the moment of incision, and thus enable not only the recording of the patient's "flight" through the anesthesia but also monitoring and allowing for any differences between the patient on the operating table and the model data based on a statistically relevant sample of patients. "SmartPilot View is particularly useful for helping young anesthesiologists control the course of anesthesia and the dosage of drugs," says Martin Luginbühl. "It's therefore ideally suited for training purposes."

Professor Jürgen Schüttler, Director of the Department of Anesthesiology at Erlangen University Hospital and President of the German Society of Anesthesiology and Intensive Care Medicine, agrees. At the same time, he also underlines the solution's importance in supporting processes beyond the operating room. "First of all, it improves the overall course of recovery when the patient is not sent into an unnecessarily deep narcosis," he explains. "And secondly, it reduces the wakeup time and therefore relieves the burden on personnel in the recovery room." Moreover, there is also a possibility that the SmartPilot might find a use in the intensive care unit. "If it can be adapted to the parameters of a medically induced coma," says Prof. Dr. Jürgen Schüttler, "then it could bring huge benefits in this area of hospital activities as well." **Frank Grünberg**

Plain Little Pellets

Dräger has always made **SODA LIME** in house, for its anesthesia devices and closed-circuit breathing apparatus. It may look a little like cat litter, but it is developed and produced using a high-tech process.

Quality starts at the beginning: From the raw paste to finished soda lime, in cartridges and ready for use—Thorsten Peters and six employees have the entire process chain well under control.

THE RIGHT TOUCH: Thorsten Peters takes a small lump of white soda lime paste in his left hand and scrapes part of it off with the thumb of his other. The Process Technician—who originally trained as an Electrician—can tell whether or not the paste has the correct properties for further processing, simply by studying the shine of the fresh surface. Peters is standing in a large hall, where soda lime is manufactured 24 hours a day, 365 days a year. “We develop and manufacture our soda lime ourselves, so we can ensure that everything works together trouble-free,” says Mechanical Engineer Benoît Donot, explaining the reasoning behind the concept. As Project Manager, Donot planned and supervised expansion of production, while his colleague Peters was in charge of the move from the old production location to the large factory hall on Revalstrasse, Lübeck, Germany.

Soda lime. It absorbs carbon dioxide from exhaled air flowing through it (see also box p. 22). In fact, the world’s first anesthesia device with a rebreathing system (1924) relied on a development from Dräger’s plant. At a glance, today’s granules look a little like cat litter, only whiter and in the form of half-round (planoconvex) lenses, each weighing in at just 25 milligrams. The cartridge of a CLIC disposable absorber contains about 40,000 of these pellets, which in total have an internal surface area roughly equal to that of a soccer field. As Peters explains, only this regular form of soda lime can ensure the high efficiency and consistently reproducible performance that is the objective of in-house production.

Until the end of the 1970s, production in Lübeck was exclusively in the form of broken lime, which was always irregular in texture, despite careful comminution into defined grain sizes—and so suffered from associated inconsistencies in its properties. Manufacturing the material was a very dusty process, and this undesirable formation of dust continued to cause problems: The sharp edges of the grains rubbed against one another during transport in containers and cartridges, remembers Thorsten Peters. In addition, formation of unwanted channels through the broken lime was a recurring problem during its use—the respiratory air would take the path of least resistance through the irregular lime, forming channels. These channels in turn reduced the contact time, and therefore the useful life of the soda lime.

Recipes for every application

The quality of the soda lime thus clearly has a decisive effect on how the overall system functions. That is another reason why Dräger keeps the entire production chain in house. “Thanks to the company’s wide range of recipes, it can make sure that anesthesia devices with rebreathing systems or closed-circuit diving and breathing apparatus function optimally for their specific application and according to the latest technology,” says chemical engineer Annette Kosegarten, explaining a decision made in 2002 that called for initially putting two production lines in a new hall—to which a third line was recently added, in order to keep up with the strong demand.

Machines developed in house ensure efficient production, all the way to the cartridge-filling stage.

The production sequence is basically the same for all lines and all recipes. Highly reactive and pure white lime from a specific quarry in central Germany is exclusively used for the starting material, because, as Kosegarten says, quality starts at the beginning.

The food-grade ground lime is delivered in semi-trailers capable of transporting up to 26 tons, and compressed air is used to blow the material from the trailer tanks into the silos. Water and other chemicals are then added to form a paste. This triggers a strongly exothermic reaction, rapidly releasing enormous amounts of heat.

Parallels with industrial baking

“For reasons related to environmental protection and economics, the company uses a cyclic system,” explains Donot, who has also saved significant amounts of energy by utilizing the reaction heat. Calcium hydroxide is the main constituent of the paste. The most important minor component is sodium hydroxide, which serves to accelerate the desired reaction with carbon dioxide. Additional chemicals, for example in the Drägersorb Free soda lime, which was developed for use in anesthesia, prevent the formation of unwanted decomposition products, which can occur in contact with standard halogenated inhalation anesthetics—particularly in low and minimal flow anesthesia. These recipes also include an indicator to show when the CO_2 has dissolved in the water of the soda lime and formed carbonic acid. The pH value changes from basic to acidic, >

A hall full of details that deserve to be patented: Every production step is optimized for perfectly consistent quality.

> causing the previously white-colored indicator to turn distinctly violet. This provides a clearly visible signal indicating that it is time to change the absorber.

The parallels between the production of soda lime and industrial baking, which also relies on secret recipes and process steps, should already be apparent—and they are unmistakable in the next steps. After being placed in a vat, the paste is granulated. The pellets of soda lime are dried and shaken out of a mold. And that is it, finished. Yet even the steps from the paste to the pellets are the fruit of many patent-worthy processes and long series of experiments. Dräger specified and developed the machines in close collaboration with plant engineers, Donot says, referring to the construction of the production line. The process involved give and take between equal partners. An open exchange of ideas and a transparent, fair price for the machinery lead to constant but affordable improvements, adds Peters, who also uses a concept called TPM (Total Productive Management), which makes it possible for suggestions for improvement from production personnel to be rapidly implemented in the production process.

Making an impact

The smooth, stainless steel walls of the drying cabinets, in particular, conceal lots of refinements. Even the fittings of the doors hold a few secrets. And that is even more true of the drying process, as Peters says, because the company wants to achieve consistent results with a minimum heat energy. Otherwise the soda lime pellets will fracture, leading to irregular shapes and an increased tendency toward dust formation during container transport. Baking oven manufacturers test their designs in a similar way, using a cookie dough that reveals the scope for improvement if it displays uneven browning. Once we get to the beater, Peters is wavering between pride in the design, which is unique in terms of the material and technology used, and the essentially secret nature of one of the central production steps. This module is equally important in terms of quality and cost-effectiveness, and it is the result of a great deal of inventiveness.

Before the soda lime pellets go on to be packaged, samples are taken and subjected to strict checks in the in-house quality assurance department. Only after this step it can be released for filling. Disposable absorbers, changeable even during the operation thanks to the CLIC concept, have become standard in anesthesia, ensuring even greater utilization of the absorber filling and thus reducing costs, says Peters. Automatic checks are carried out at every step, from filling the absorbers to sealing to packing into cartons.

A total of six employees manufacture soda lime, using a fully automated process in a hall half the size of a soccer field—with less dust to be found than you would expect to see in the back corner of a closet. The computer-supported processes can be remotely monitored and controlled via the Internet, Peters reports. The team ensures that a consumable material upon which lives depend will continue to be produced in Lübeck—in consistent quality, for various purposes, and in increasing quantities. **Nils Schiffhauer**

The right chemistry:

Exhaled air contains around four percent carbon dioxide. Soda lime removes this CO_2, so that the remaining air—enriched with oxygen—can be fed back into the breathing circuit. The process takes place in a number of steps:

- Carbon dioxide and the water contained in the soda lime react to form carbonic acid: $CO_2 + H_2O = H_2CO_3$
- In the second intermediate step, the carbonic acid reacts exothermically with sodium hydroxide to form sodium carbonate and water: $H_2CO_3 + 2\ NaOH = Na_2CO_3 + 2\ H_2O$ + heat
- Finally, the sodium carbonate reacts with the slaked lime to form calcium carbonate and sodium hydroxide: $Na_2CO_3 + Ca(OH)_2 = CaCO_3 + 2\ NaOH$

100 grams of soda lime can absorb up to 15 liters of carbon dioxide. The soda lime produced by Dräger utilizes the kinetic limits of these reactions to a very high degree.

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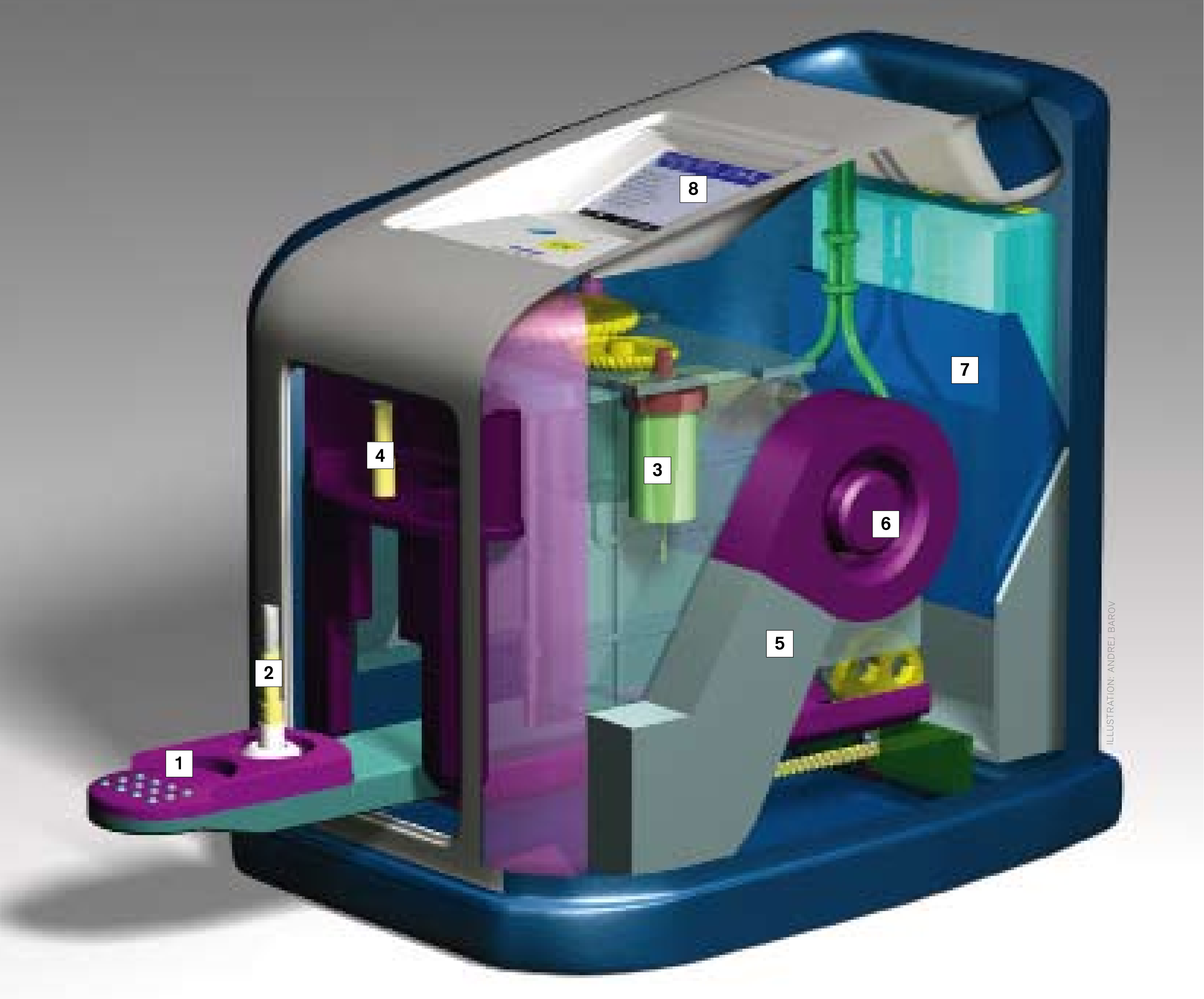

ILLUSTRATION: ANDREJ BAROV

Drug Test from Saliva Sample

A saliva-based drug test can offer an alternative to conventional urine tests in hospital emergency rooms, emergency physicians' offices, and other medical facilities. About 0.0003 liters of saliva are sufficient for the Dräger DrugTest 5000 to provide reliable, mobile, and fast detection of all commonly encountered narcotics. In a few steps, the unit tests for amphetamines, designer amphetamines, opiates, cocaine and its metabolites, benzodiazepines, and cannabinoids.

The test cassette [1] with its integrated oral fluid collector [2] is slid into the analysis unit. Once the unit's door is closed, the inserted buffer cartridge [3] is automatically [4] lowered by a motor. The contents of the cartridge wash out the sample. A sophisticated temperature and ventilation system [5], [6] ensures constant reaction conditions, thus ensuring a precise measurement. An integrated rechargeable battery [7] supplies the unit with power and ensures its mobility. The optical sensor unit evaluates the characteristic reaction pattern on the test strip with high precision, and results for each individual substance class are clearly displayed on the LCD screen [8].

The embedded microprocessor can store up to 500 data sets — in addition to controlling the entire DrugTest 5000, and the Analyzer immediately signals operating errors both acoustically and optically, ensuring the quality of the procedure. The unit features a number of different interfaces (PS2, USB, IR) e.g. for a keyboard or a barcode scanner. This allows not only input of personal data, but also hard-copy documentation by means of a printer.