



Ivan and John with the HYVAN.

PHOTOGRAPHS: JULIET NICHOLAS

# Bright IDEA

A LITTLE MACHINE THAT IS THE BRAINCHILD OF TWO KIWIS IS DESTINED TO MAKE A BIG DIFFERENCE IN THE MEDICAL FIELD.

*By Sue Allison*

**T**he blue and yellow metal carry box sitting on the table looks as though it might contain a small dog, or maybe a large sewing machine. With the lid off, it appears to be some sort of coffee-making machine. But it's none of the above. This is an ingenious portable anaesthetic machine, the brainchild of John Hyndman and Ivan Batistich.

Born in a backyard shed and named HYVAN by its progenitors, the little machine has the potential to make a big difference to surgery throughout the developing world as well as disaster zones. It won the Kiwi duo this year's New Zealander of the Year Innovator award and, in August, they

will receive an innovation award at the World Congress of Anaesthetists in Hong Kong.

John is an anaesthetist in Christchurch and Ivan an engineer, formerly from Auckland but now based in Thailand, with expertise in the medical engineering field. Both men have spent time doing volunteer work in the Pacific Islands and Indo-China and experienced first-hand the frustrations and limitations faced by doctors working in low-resource countries.

"A lot of gear is donated to these places and it's great gear, but it's usually very sophisticated technology. The

hospital workshops are really capable when it comes to patching things up and improvising, but not repairing high-tech electronic gear where they haven't got parts," says John.

"These places are graveyards for anaesthetic machines. Often within a week or two something goes wrong and they can't fix it, so it sits in a corner rusting. I thought what they need is something really simple, cheap, easy to maintain and absolutely reliable."

And he knew just the man to make it. Ivan already had a reputation in the medical world for developing ingenious products, particularly the IVENT—a portable ventilator he designed and



The HYVAN with the cover and self-inflating bag.

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manufactured in his Auckland garage 25 years ago and which is still used throughout the world.

## Upgraded version

“It’s an extraordinary little machine,” says John. The HYVAN has an upgraded version of Ivan’s ventilator as its nucleus, with attachments to create a continuous-flow anaesthesia machine, and all assembled within a lightweight, pressed-aluminium body.

General anaesthesia has three main goals: unconsciousness, paralysis and pain relief. Today’s machines use modern equivalents of liquid ether, such as sevoflurane, which is vaporised and added to the flow of oxygen to keep the patient asleep. The patient breathes out a lesser concentration of these gases plus carbon dioxide, which

is removed by passing the exhaled air through a canister of soda lime. These gases are topped up with sevoflurane and oxygen and recirculated. As the patient is paralysed, the ventilator acts as bellows to keep their lungs working.

Various valves control the intake of the gases and ensure they go only in one direction, while gauges measure their flow rate. The machine also monitors the patient’s electrocardiogram (ECG), heart rate, blood pressure, inspired and expired gases, volatile agents, oxygen saturation and temperature.

Ivan and John’s machine, which has been 12 years in the making, does all these things and at a fraction the cost and size of a regular hospital anaesthetic machine. Modern hospital machines, which are the size of large fridges, cost around \$200,000. The Hyvan weighs in at just 15kg and projected costs are around \$15,000.

Moreover, it is not dependant on a power supply. The ventilator is pneumatically driven and can be powered by compressed air or compressed oxygen if there is not a mains power source. The electronics are operated by a 12-volt rechargeable battery, which has the added advantage that the machine is not “live”. If all else fails, the patient can be kept alive by operating the ventilator by hand.

## Old-fashioned

John says they haven’t invented anything. “We’ve just collected ideas, simplified things and applied modern electronics. In a way, we’ve wound back the clock and used technology similar to what was around 30 or 40 years ago when things were a bit more hands on.”

The HYVAN has old-fashioned flow meters—the little ball visibly showing the gas level—whereas latter-day machines display flow with LED-lit



John with a high-tech anaesthetic machine (AISYS) used in New Zealand hospitals.





The inspiratory and expiratory patient hoses.



The empty soda lime absorber.

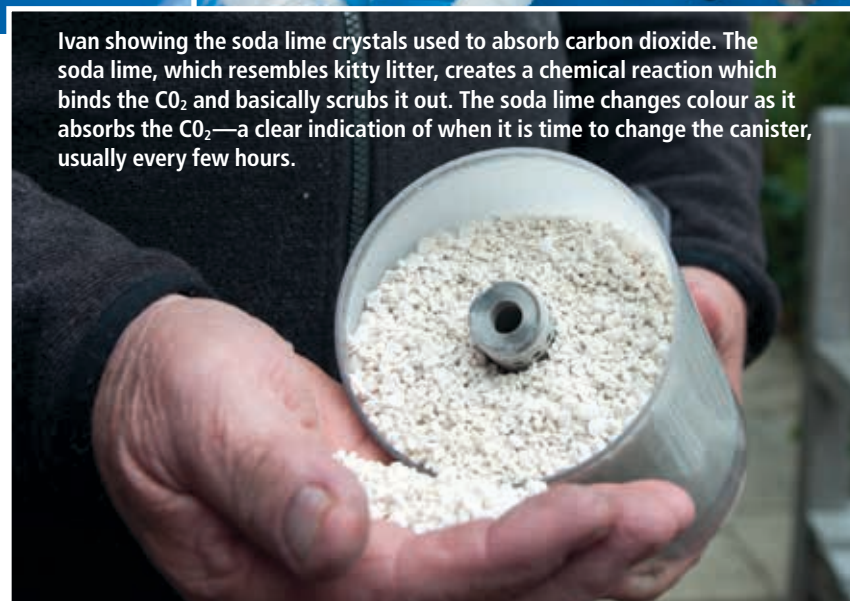
*“We’ve just collected ideas, simplified things and applied modern electronics.”*

numbers. “Not everybody wants that electronic gadgetry. With this thing you are in control.

“Ivan’s got the ability to simplify anything and make it robust. Anything Ivan makes will work,” says John. “The HYVAN is a product of Ivan’s fertile imagination, knowledge and long experience. He’s an unassuming man who shuns the limelight, but the reality is that he is the architect-engineer-builder and I’m the project manager.”

A farmer’s son from Kaitaia, Ivan combines a creative mind with a practical approach and tends to tackle problems from left-field. He designed and made the early prototypes in his Auckland garage workshop, where he worked from home while nursing his wife, who developed multiple sclerosis soon after their marriage, for 40 years.

While doing volunteer work in the Cook Islands, Ivan devised an oxygen concentrator which cut the costs from around \$300 a bottle to just \$12 in Rarotonga’s hospital—an enterprise



Ivan showing the soda lime crystals used to absorb carbon dioxide. The soda lime, which resembles kitty litter, creates a chemical reaction which binds the CO<sub>2</sub> and basically scrubs it out. The soda lime changes colour as it absorbs the CO<sub>2</sub>—a clear indication of when it is time to change the canister, usually every few hours.

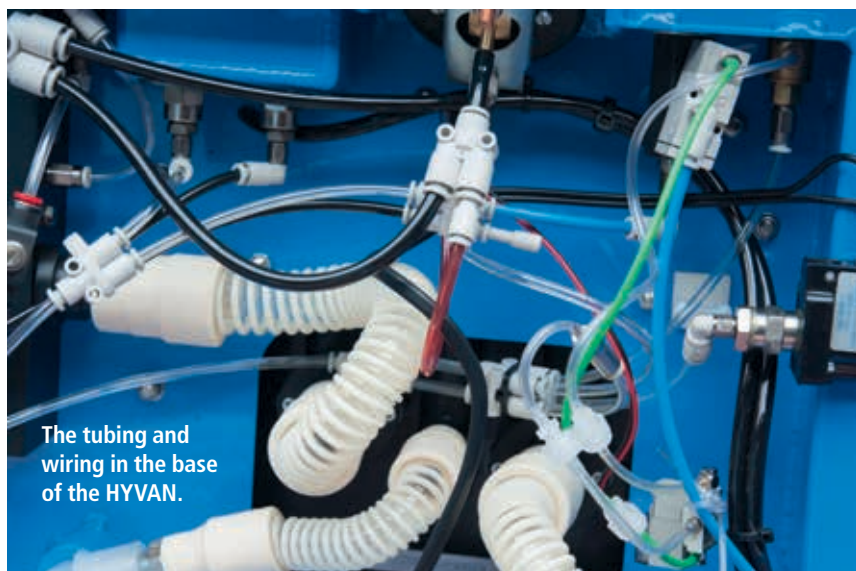
which was recognised with an award from the NZ Society of Anaesthetists. There are also plenty of grateful mothers in the islands after he rigged up a ventilator with nitrous oxide in a birthing room that previously had offered no analgesia.

Ivan has also been involved in the veterinary side of anaesthesia, developing equipment which put an end to the high death toll during embryo transfer with valuable Cashmere goats in the 1980s.

## 12-year project

Both men combine intellect with Kiwi practicality. John was studying to be a geologist when his father

persuaded him to apply for medical school. His Irish father, who had trained as an engineer in Ireland, switched to medicine himself after a life-changing stint in India during World War II helping make medical equipment for the army surgeon. “I really did medicine to appease him, but I’ve got no regrets. I’ve really enjoyed it,” says John, who admits his initial plan was to do medicine, make a lot of money and buy a farm. And he has got a little farm. John lives on 5ha north of Christchurch, where he and his wife Daphne have alpacas, olive trees, two dogs and a number of sheds. The one where the HYVAN and its earlier prototypes dwell



The tubing and wiring in the base of the HYVAN.

doubles as a bedroom for Ivan when he is in town.

The two men, who say they have never had a cross word during the 12-year HYVAN project and have made no formal ownership agreements, are driven purely by altruism. “We have never seen it as a money-making venture. We just saw a need,” says John. “When money comes into it things go wrong.”

They have already put their hands deep in their own pockets to get it to this stage.

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“If the HYVAN proves successful, its success in large part will be due to its durability, reliability and affordability,” he says. But they know they can forget profitability. The sad reality is

that big companies aren’t interested in serving the Third World. To make their profit margin worthwhile, they want to sell machines worth \$200,000, not \$15,000.

John and Ivan are keen to keep control of the project and manufacture the HYVAN in Christchurch (although John, originally from Dunedin, is resisting Cantabrian pressure to change its distinctive yellow and blue Otago colours to red and black).

John says he managed to recruit two local people who were crucial to the finished product.

## Creative design

“The first HYVAN prototype was a real Heath Robinson effort. Stephen Cutler, a young design engineer here in Christchurch, transformed it with his remarkably creative design skills, while Nick Parker, a gifted software engineer, did a superb job with the ventilator electronics and the complex alarm system. I still marvel at how he achieved this.”

The HYVAN’s alarm, a bird-like chirping, is activated when pressure readings fall to 50 percent of their original setting.

## Simple solution



The CPAP (continuous positive airway pressure) valve. Ivan’s ingenious valve system allows the anaesthetist to dial up the required CPAP.

The larynx (voicebox) is at the top of the trachea (wind pipe). The two vocal cords are located at the entrance to the larynx. They act like musical reeds and the air passing through them allows us to speak and sing. These cords can also slam shut in a protective way to prevent foreign bodies from entering the trachea. This is called laryngospasm.

At the end of an anaesthetic, the patient is in a twilight state of consciousness. The cords are often super-sensitive to stimulation at this stage and saliva or irritation can cause laryngospasm. This means air can’t get into the lungs and the patient will rapidly turn blue unless the laryngospasm is reversed.

In a real emergency a muscle relaxant

is given to paralyse the cords but usually we can manage laryngospasm by applying Continuous Positive Airway Pressure (CPAP). This is applied above the vocal cords by applying a face mask firmly (air-tight seal) and pressurising the air. This CPAP usually “breaks” the laryngospasm.

“I was concerned as the HYVAN could not generate CPAP,” says John. “But Ivan had one of his brainwaves a few weeks back that resulted in us adding the CPAP BLOCK. This may be confusing but essentially it is simply a matter of removing the expiratory hose from the HYVAN and blocking the end of the hose. This raises the pressure in the inspiratory hose and gives CPAP at the facemask. A very simple, elegant solution and it works brilliantly.”





The air and oxygen flow meters.

Enztec, a local company which mainly manufactures orthopaedic equipment, has been invaluable helping with advice and componentry, while

Aimee Wilkes helped design the PCB (circuit board).

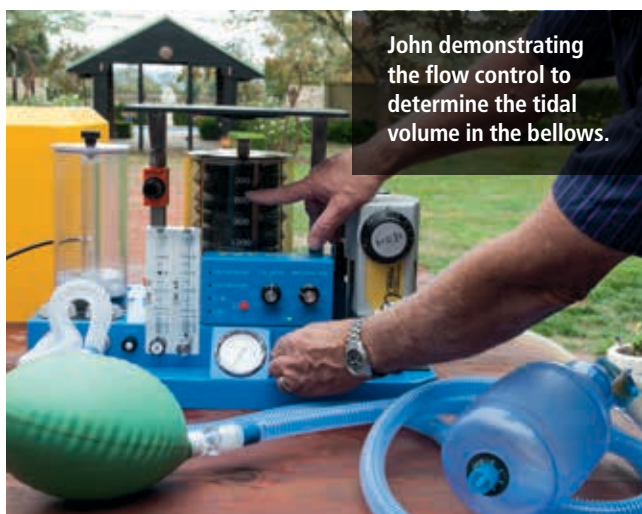
Twelve years and five prototypes on, John and Ivan are satisfied that the

HYVAN is ready. Its release has been delayed while they put it through the hoops to gain ISO 13485 (medical devices) certification, which is essential even in the Third World now.

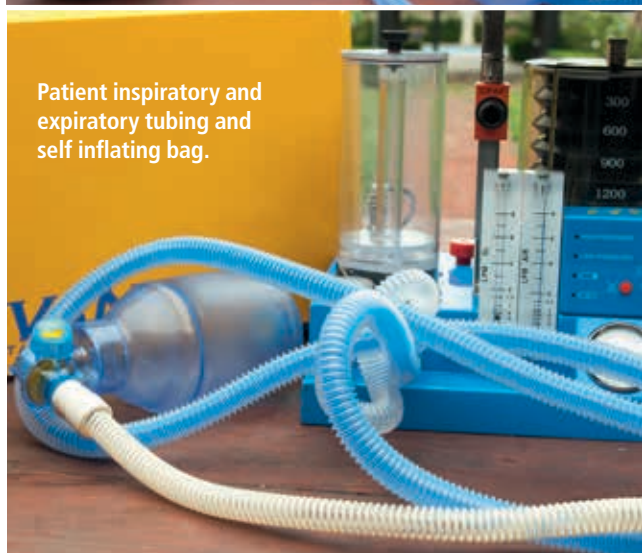
“It’s expensive and it’s held things up, but it’s necessary and will be huge for marketing,” says John. Initially, Ivan made many of the components himself. Now most of it is off-the-shelf stuff, except the metal parts. The flow meters, gauges and vaporisers are standard medical supplies, many picked up by Ivan during visits to medical exhibitions in China.

## Evaluation

“Once we decided on ISO 13485 we had to move to ISO certified components as Ivan’s creations were not. A pity in some ways as Ivan’s were often superior to the ISO alternative,” says John. The next step will be getting a CE mark, mandatory for marketing in the European Economic Area (EEA).



John demonstrating the flow control to determine the tidal volume in the bellows.



Patient inspiratory and expiratory tubing and self inflating bag.



The HYVAN electronic control box and flow meters.

## Medical breakthrough



John demonstrating the old fashioned method of anaesthesia—dripping a volatile agent onto lint-covered, steel wire mask.



John says a visit to Nelson's flagship, *Victory*, in Portsmouth, while he was in the UK as a young registrar, was a sobering experience. "The surgeon's quarters were below deck and there was a brazier in one corner. All they did was amputate. A good surgeon could chop off a leg in 30 seconds. They would fill them up with rum, saw off the limb and cauterise the wound with a branding iron. That was 1805. It's not that long ago. Then in 1840, along came ether. It was one of the great breakthroughs in medicine."

Nitrous oxide was used after British chemist and inventor Humphry Davy decided to find out by experimenting on himself in 1779. He was startled to discover that it made him laugh, so nicknamed it laughing gas. It wasn't until 1844 that it was used for anaesthesia by American dentist Horace Wells. Ether, a hydrocarbon which may have been synthesised as early as the 8th century, was used as a recreational drug in the early 19th century. American physician Crawford Long saw its potential in surgery when he noticed that his friends felt no pain when they injured themselves while under its influence and used it as an anaesthetic for the first time in 1842 to remove a neck tumour.

Ether's explosive flammability and tendency to produce excessive vomiting lead to chloroform, which had been

first synthesised in the 1830s, being favoured in the United Kingdom, particularly on the field in war-time. How ether works is still a bit of a mystery, but it not only puts people to sleep but also paralyses them while they are unconscious. The modern equivalents of ether, such as sevoflurane, isoflurane and desflurane, are halogenated ethers (ie, they are halogen rather than hydrogen-based) and have the advantage that the patient is asleep within seconds and wakes quickly after the operation.

The first anaesthetic "machine" was a wire cage mask which held an ether or chloroform-infused rag over the mouth and nose.

Drugs given to induce general anaesthesia can be either as gases or vapours (inhalational anaesthetics), or as injections (intravenous anaesthetics). Most commonly the two forms are combined, with an injection given to induce anaesthesia and a gas used to maintain it.

In 1917, Henry "Cocky" Boyle, who worked with the Royal Army Medical Corps in London during World War I, developed the continuous-flow anaesthesia machine, which is the forerunner of all modern machines. He was left-handed so anaesthetic machines traditionally have controls and switches for left-hand use.

The HYVAN passed a recent hospital evaluation with flying colours and, once certified, will be put to use in the field—probably in Indo-China—later this year. In August, they will demonstrate it to 12,000 anaesthetists at the World Congress in Hong Kong—an ideal launching pad.

But today it is sitting in the sun on a

rustic table on John's verandah. Ivan is trying to rig up a long extension cord to the compressor with the help of his stepson, who is out from Thailand. John is on the phone to a neighbour who is bringing his alpaca over to be mated. The strange creatures are shuffling expectantly in the paddock and the dogs are

barking their heads off in the yard. There's a barrow-load of weeds halfway down a border, the smell of baking coming from the kitchen, a couple of small grandsons lurking about and No.8 fencing wire as far as the eye can see. All in all, perfect laboratory conditions for a couple of inventive Kiwis. 