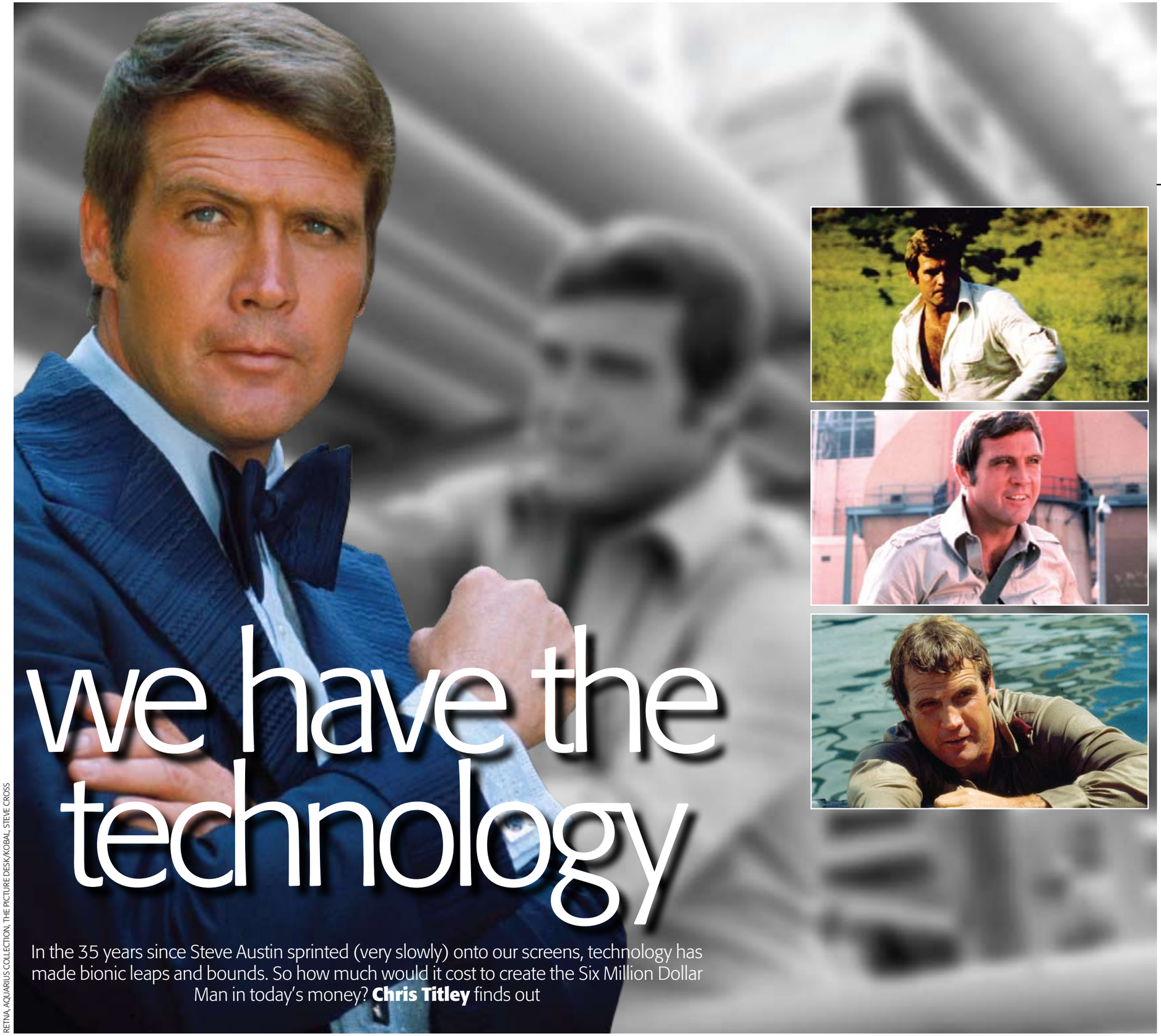


we have the technology

In the 35 years since Steve Austin sprinted (very slowly) onto our screens, technology has made bionic leaps and bounds. So how much would it cost to create the Six Million Dollar Man in today's money? **Chris Titley** finds out

RETNA, AQUARIUS COLLECTION, THE PICTURE DESK/KOBAL, STEVE CROSS

DETAILS

HOW STEVE AUSTIN WAS REBUILT

BIONIC EYE: restored his sight and gave him a 20x zoom. It could also see in the dark, detect heat and provide an accurate targeting device

BIONIC LEGS: his top speed was never established, but he could give your 1970s Ford Escort a run for its money

BIONIC ARM: said to have the power of a bulldozer, it could lift cars and hurl a ne'er-do-well to the other end of the street

"STEVE AUSTIN. Astronaut. A man barely alive. Gentlemen, we can rebuild him. We have the technology. We have the capability to make the world's first bionic man.Steve Austin will be that man. Better than he was before. Better. Stronger. Faster."

If these words conjure up memories of you running round the playground in slow motion while humming a certain theme tune – Da-da-*da*-daa – it's odds on you're a child of the 1970s.

The 'Six Million Dollar Man' was required viewing during its weekly ITV run between 1974 and 1979. Its plot, based on Martin Caidin's novel 'Cyborg', tapped into the widespread belief that medical science was advancing so rapidly it couldn't be long before our every injury or ailment was fixable by a new breed of doctor-engineer.

As the opening titles explain, astronaut Steve Austin's lunar landing vehicle had crashed on a test flight. The US government decides to splash out $6m refitting the mangled starman, deploying the cutting-edge nuclear-powered technology of boffin Dr Rudy Wells.

But Steve's new parts don't make him just as good as before: they make him better. Tin legs enable him to run at 60mph (always in slo-mo for some reason), his artificial bicep can fling a bad guy into any number of empty cardboard boxes, and his camera-powered eye zeroes in on the least hint of trouble.

Part invulnerable robot, part frail human, he is a hybrid hero who caught the 1970s public's imagination. So much so that the inevitable spin-offs arrived thick and fast: the bionic woman, the bionic boy, a bionic dog and even a seven million dollar man who, according to Jeff Evans in 'The Penguin TV Companion', "blows a fuse and Austin has to destroy him".

Today, Steve Austin sits on the top of a teetering scrapheap of futuristic forecasts. The age of the cyborg has failed so far to dawn, and $6m is won every other week on the lottery.

But, 35 years since ITV first broadcast the show, how close is science to creating a real bionic man? Could we rebuild him – and if so, how much would such a mechanical makeover cost?

Advances in prosthetics have certainly accelerated in the last decade. We set out to discover if science has created a match for Steve Austin's bionic bits and pieces, and then tot up the final bill.

ARGUS II: BIONIC EYE

The best fit for the bionic eye is the Argus II, which is more accurately the artificial retina developed by Second Sight, a California-based medical company. In clinical trials – some carried out by a team at the Moorfields Eye Hospital in London – blind patients fitted with the device have reported some restored vision, to the extent of seeing areas of light and vague shapes where before there was only darkness.

Argus II is specifically aimed at helping people who have lost sight due to retinal damage caused by diseases such as retinitis pigmentosa.

Surgeons attach an electrode-studded array to the retina with a microtack the width of a human hair. The patient then wears sunglasses with a tiny video camera and transmitter built in, powered by a microprocessor and battery worn on the belt.

Images captured by the camera are converted into an electronic signal and transmitted to an implanted receiver. It sends the signals through a tiny cable to the electrode array, stimulating it to emit electrical pulses.

These induce responses in the retina that travel through the optic nerve to the brain, which perceives patterns of light and dark spots corresponding to the electrodes stimulated.

Some 30 patients have been implanted with the Argus II, says Second Sight's Gregoire Cosendai. All of them can see light, and some can see more. "We have people who will tell you they have seen the moon for the first time in many many years.

"Sometimes the system is helping them to do very basic tasks like seeing the difference between a cup and a plate on the table. But it's very basic ▶

BIONIC MAN TIME LINE

1958
Dr Jack Steele coins the term 'bionics'. The first artificial pacemaker is fully implanted into a human patient, at Karolinska University Hospital in Sweden. It lasts three hours.

1961
A computer-operated mechanical hand is developed at MIT

1962
High-density polythene, used in artificial hip joints, is developed

1978
The multi-channel cochlear implant, which allows the recipient to hear by mimicking the function of the cochlea, is developed

1987
A patient with advanced Parkinson's disease is fitted with a deep-brain electrical stimulation implant

2000
An artificial silicon retina is implanted into a human eye. The artificial retina is made from silicon microchips which contain thousands of tiny light-converting units.

2001
Amputee Jesse Sullivan receives a fully robotic arm developed by the Rehabilitation Institute of Chicago. The arm has a nerve muscle graft which allows him to use his own thoughts to move the artificial limb.

2007
Oscar Pretorius wins silver at the South African National Athletics Championships against able bodies competitors with his artificial Cheetah limbs.

◀ information they get out of it at this point. It's the beginning of a new science. No one had done retinal stimulation before."

The technical challenges ahead for such visual innovations are daunting. For a start, any device must be small enough to fit into the eye. And scientists are still not certain precisely which cells in the retina they are stimulating.

But Cosendai is hopeful about future developments. "I am fairly confident that within a period of time – I don't know whether it's going to be 15 years or 50 years – people with a retinal implant are going to be able to read."

Steve Austin's bionic eye gave him telescopic vision and enabled him to see in the dark. If the Second Sight technology can be developed to the point where it communicates with the brain, 'super vision' will be possible, Cosendai predicts.

"It's probably very simple to use a retinal implant that already talks to the brain to provide the patient with – who knows? – an infrared image and then they could see in the dark. Or see at longer distances."

Cosendai says that the cost of developing the Argus II was astronomical, but the price would drop when it went into full production.

By comparison the cochlea implants made by the company now cost about $30,000, which seems like a reasonable estimation for our bionic eye.

I-LIMB: BIONIC HAND

The i-LIMB is the world's first fully-articulating, commercially-available bionic hand. Created by Touch Bionics it features a highly intuitive control system that uses a traditional two-input myoelectric (muscle signal) to open and close the fingers.

A patient fitted with the hand can not only move their fingers but can "grasp with a full power grip, they can use the index finger for touching key pads, they can hold the thumb onto the index finger and rotate keys or hold credit cards", according to Hugh Gill, director of technology and operations for Touch Bionics.

"Because the signal is proportional to voltage, if the patient makes a small movement there'll be a low voltage, the hand will move slowly. If the patient puts in a higher impulse the muscle signal voltage will increase and the hand will close quicker."

What about the hand's strength? The average person can apply about 30kg of pressure in their hand; the i-LIMB is limited to between 10-12kg. There's nothing to stop you applying much more power to a prosthetic hand than a human hand could manage, says Gill, "but the problem in doing that is that individual could cause damage to other individuals".

The inclusive price for the i-LIMB Hand, socket build, clinical services and associated components is around $66,000

OSSUR POWER KNEES: BIONIC LEGS

International prosthetics specialist Ossur is the company that created athlete Oscar Pistorius' famous Cheetah running blades. The double amputee subsequently grabbed three sprint golds in the Paralympics, and, more astoundingly still, a silver competing against able-bodied sprinters in the South African National Championships.

With pioneering products like the Power Knee, Ossur have gone a stage further – and put power into prosthetics. Not only does the battery-powered motor replace the lost muscle power, the device's sensors measure motion, position and velocity of the sound leg, providing feedback to the built-in processor. That helps the Power Knee to anticipate the motion on the prosthetic side even before the next step takes place.

Ossur UK specialist prosthetist Richard Hirons says ensuring power is applied at the right time in the walking cycle was one of the biggest challenges. Engineers then had to ensure the device was quiet, light, reliable, and could adapt to different walking styles and various surfaces.

He says the purpose of the Power Knee is to replace the energy lost through amputation. A person with only one leg has to put in 100 per cent more effort than an able-bodied counterpart.

What about a double amputee, like Steve Austin? "Again the biggest issue is energy expenditure," says Hirons. "Someone with two amputations over one would have to put in almost as much additional effort to walk the same speed and distance as their able-bodied counterpart."

Mind control is next. "The absolute next stage is when we connect directly with the neural pathways of the body so we can either have conscious or sub-conscious control of a prosthesis like the way we do with our own limbs. That's the missing link at the moment."

A breakthrough may not be too far away. Hirons cites the work of Kevin Warwick, Professor of Cybernetics at the University of Reading, who has implanted electrodes in his own arm to link his nervous system directly to a computer.

Ossur's current devices are deigned to amelioarte disabilities rather than give someone superhuman power, Hirons says. "No matter how much we use the words like powered, bionic and sensor-controlled, all these devices are doing is trying to minimise that additional energy expenditure. We still haven't got to the point where they have a net energy benefit, where they would be better than the able-bodied."

But could the future deliver powered limbs that allow us to run as fast as a cheetah? Maybe, muses Hirons, if they were combined with developments in exoskeleton technology.

Approximate cost of a Power Knee: $63,000 each.

EXOSKELETON: BIONIC STRENGTH

Steve Austin never flagged, even when carrying mammoth weights. To match him, all you need is a powered exoskeleton.

Berkeley Bionics is the leader in this field. The US university spin-off firm has developed an exoskeleton comprised of two powered anthropomorphic legs, a small on-board computer and a backpack-like frame for bearing weights which no unenhanced human could carry for long.

WHAT PRICE TODAY'S BIONIC MAN?

Thirty-five years ago, it cost the US government $6m to rebuild Steve Austin – about $26m in today's money. Today the technology is still not quite advanced enough to match the Bionic Man in every respect. His bionic eye, for instance, could do little more than distinguish light from dark, and his bionic legs could propel him at walking pace and no faster.

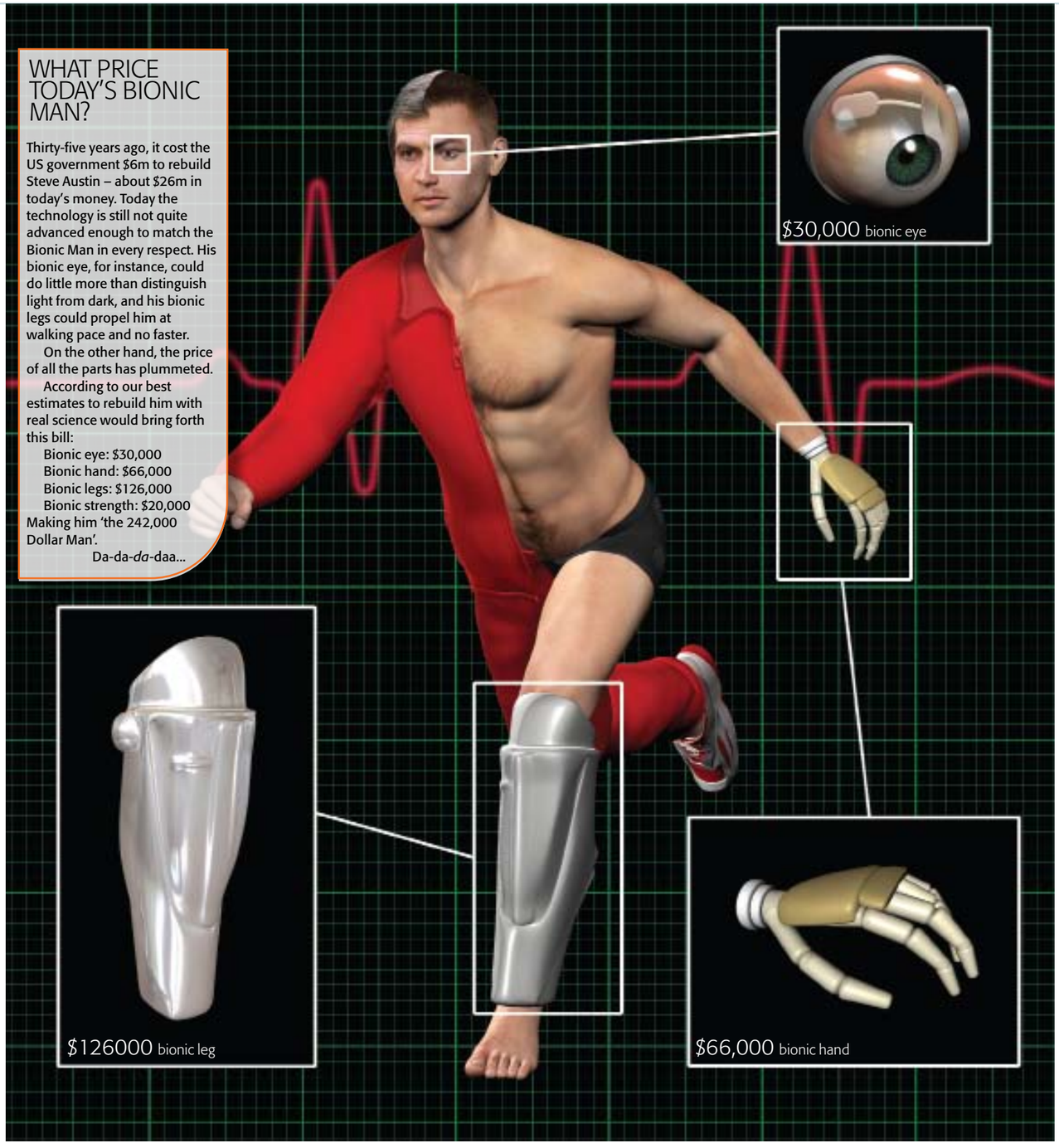
On the other hand, the price of all the parts has plummeted.

According to our best estimates to rebuild him with real science would bring forth this bill:

Bionic eye: $30,000
Bionic hand: $66,000
Bionic legs: $126,000
Bionic strength: $20,000

Making him 'the 242,000 Dollar Man'.

Da-da-*da*-daa...



The wearer can carry significant loads on his or her back with little effort over any type of terrain for hours. And, thanks to computer analysis, the exoskeleton soon moves in concert with the person inside.

"The design of this exoskeleton really benefits from human intellect and the strength of the machine," says Homayoon Kazerooni, founder of Berkeley Bionics. More than 40 sensors and hydraulic mechanisms function like a human nervous system, constantly calculating how to distribute the weight being borne and create a minimal load for the wearer.

"There is no joystick, no keyboard, no push button to drive the device," says Dr Kazerooni, a professor of mechanical engineering. "The pilot becomes an integral part of the exoskeleton."

There are numerous applications for this technology: it could give disaster relief workers, firefighters and other emergency personnel the ability to carry major loads such as food, rescue equipment, first-aid supplies and communications gear without any strain.

Unsurprisingly, though, it is the US military that is keenest to exploit the potential. The design has been licensed to global security company Lockheed Martin, which is now taking orders for the HULC – Human Universal Load Carrier – "an advanced robotic exoskeleton designed to augment soldiers' strength and endurance and prevent their premature fatigue".

The specs are impressive. The incredible HULC can carry up to 90kg – around the average weight for an adult male in the US – travel at 11km/h for long durations, and fit a soldier of any height between 5ft 4in and 6ft 2in. It also has handy attachments for lifting artillery shells or carrying a SWAT ballistic shield.

As you might expect, the price of this fancy bit of kit is kept strictly on a need-to-know basis. But Dr Kazerooni's feeling was that the cost of a general powered exoskeleton would come in at about $20,000. ■

■ **See these developments in action at:**
http://kn.theiet.org/magazine/videos