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MAGAZINE OF THE YEAR

Snowboard gadgets

5 top techno extras for the winter slopes *p93*

Welcome to the new AGE OF STEAM

From sports cars to satellites, why the daddy of all engines is back for good *p24*

Prehistoric stargazers

Unravelling the mysteries of ancient astronomy *p59*

Are bacteria or viruses carried in clouds? *p55*

Biorhythm genetics

How nature's rhythms are written in your DNA *p66*

PLUS » How to fit 60 DVDs worth of stuff on one disk *p44* » The 5 best green-themed films for 2008 *p73* » Wireless home security systems put to the test *p87* » Why does January give you the blues? *p35*

STEAM machines

It seems Victorian engineers were onto something. The vehicles of the future could be powered by steam, as **Robin Hague** reports

THERE'S NOTHING PARTICULARLY UNUSUAL about a car racing at 200mph across the Bonneville Salt Flats. If anything, 200mph (320km/h) is a bit pedestrian for this part of northwestern Utah, USA, where hundreds of land speed records have been broken in the past 100 years. But August will see a slightly different vehicle streak across the brilliant white landscape. Known as the Inspiration, it might have the look of a typical speed car: a low, aerodynamic bullet in classic racing green. But what will set this vehicle apart from the rest of the field is the gentle plume of water vapour trailing behind its fins. It's not overheating – it's powered by steam.

Unlikely as it sounds, steam power, that mainstay of Victorian engineering, is undergoing a renaissance. And its image as a slow, heavy and inefficient means of power is irrelevant in the steam-punk vision for the 21st century. The Inspiration, built by a team at the British Steam Car Challenge —

BSCC's Inspiration will attempt to set a new steam land speed record in August

"No matter how old the technology, there are always new and better ways to make that technology work for humankind"

Lynne Angel Team coordinator, BSCC

(BSCC), will not only reach 200mph, but it will do so with fewer pollutants spewing out of the back. And although hydrocarbons are still required to heat water and turn it into steam in the first place, the technology nevertheless has both the efficiency and the green credentials to inspire dozens of steam-powered innovations around the world. We could soon be seeing steam-powered airships soaring above our cities, while steam-powered nano-engines work in hospitals and steam-powered spacecraft set out for distant galaxies.

"No matter how old the technology, there are always new and better ways to make that technology work for humankind," says Lynne Angel, team coordinator for the BSCC. "It is our sincere hope that we can influence the next generation of engineers and designers to take an ecological approach to solving problems."

One way to do that is to smash the world's longest-standing land speed record. The fastest steam car in history, the Stanley brothers' Rocket, topped out at 127mph (204 km/h) on Daytona Beach way back in 1906, when steam and petrol cars were fighting it out for market supremacy. Although the steam car set the record that day, petrol engines eventually benefitted from greater economies of scale and steam cars became collectors' items.

Now, over a century after the Rocket set its record, the BSCC team is hoping the Inspiration will finally better it. Designed by Dr Glynne Bowsher, the mechanical designer behind the ThrustSSC supersonic jet car, Inspiration measures 8.5 metres long by two metres wide, making it relatively small for a land speed record car (ThrustSSC was about twice the size). Powered by a 360hp steam turbine and twelve 250kw gas burners

STEAMY FACTS

Steam is the gaseous form of water and is invisible. The mist usually referred to as steam is actually water droplets condensing out of the steam

The bubbles in boiling water are bubbles of steam formed where the water has exceeded 100°C, not air being driven out of the water

Compared to the same volume of hot air, steam can lift objects twice as heavy

Can Inspiration's engine provide the power to set a new steam speed record?

– equivalent to 1500 typical electric kettles – it's also a strong contender for the cleanest. Having an external combustion engine means the fuel and oxygen is burnt outside the engine section itself. That allows for more control over the burn process, which is accomplished at lower pressures. The end result is reduced emissions of toxic nitrogen oxides and dust particles.

The process begins when boilers in the car, fired by liquefied petroleum gas (LPG), heat a tank of water to 400°C, turning it into steam. This is fed to four jet nozzles that blow steam at two sets of turbine blades, which then turn the drive shaft. The turbine spins at 12,000rpm and drives the rear wheels through a gearbox. It's a slick feat of engineering, but Angel says the most difficult part was generating the steam in the first place.

"The biggest challenge we faced was the boiler design," she says. "In theory, a boiler powerful enough to drive the car would be much larger than the whole vehicle. We have been through four generations of boiler and have tried all sorts of different approaches, but now we have them working well and there may well be spin-off applications due to their high performance."

With the boilers firing successfully, the team are planning for a busy 2008. Initial testing will take place at RAF Bruntingthorpe, where they intend to reach 100mph (160km/h) before going for the 200mph (320km/h) mark in Utah in August.

Odd one out

But while Inspiration is at the forefront of new steam, its turbine engine differs from most of the other current steam projects, which favour refined versions of the classic steam piston engine. Steam turbines resemble a fan or a water wheel, enclosed in a box and blown round by a jet of steam. They are the most efficient form of steam engine, able to utilise 40 per cent of the input energy, but are at their best when running at a constant speed. That means they are suited to more than just high-speed cars: steam turbines generate 86 per cent of the world's electricity, and are a key component in all nuclear-powered ships and submarines.

Steam turbines such as this are common in power stations across the world

In contrast, steam piston engines produce maximum force at a standstill and so generally drive the wheels directly, with no gearbox. These are ideal for ground transport where the engine often needs to speed up and slow down – such as a steam locomotive. And, as engineers find new ways to make piston engines more efficient (such as using insulation to reduce energy loss), there are now several projects aiming to build new steam trains for the world's railways.

One of them is the 5AT project. This is a scheme to build a new steam locomotive to operate alongside current trains on the UK's modern mainline network – even if, at first, it's confined to niche pleasure trips and rail cruises. The 5AT will have a top speed of 125mph (200km/h). Its designers believe it will be much more reliable than steam locomotives from the early 20th century, requiring considerably less maintenance. They

ASK THE EXPERT MATT CANDY

Engineering administrator for BSCC

Why are you particularly excited about the steamcar?
With the steamcar project we are tackling challenges that no-one has tried before. We're pushing current technology to revisit this neglected steam land speed record and will hopefully inspire more young people into engineering at the same time.

Who will be driving?
Charles Burnett III will be the principal driver. He is a well-known powerboat enthusiast who already holds a variety of world records.

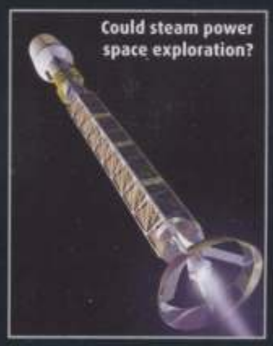
What differences will he notice from a conventional car?
There will be a big lag in throttle response – two seconds. So when you put your foot on the accelerator the car will not respond instantly. This is like the lag experienced with turbocharged cars, but much more exaggerated. The driver will also be quite warm.

What long term impact do you think the technology will have?
Our biggest innovation has been in creating such compact boiler units. The work we've done on improving burners and boilers may well help improve the efficiency of similar machinery, like power station boilers and heat exchangers.

Will I be filling up a steam-powered Volvo in 25 years?
Probably not, since internal combustion offers many advantages for cars – steam is more likely to be used in stationary applications. One possible use might be localised power generation for rural areas or developing nations.

What are the green advantages?
Steam engines can run on a wide variety of sustainable fuels. Also, having a dedicated area for combustion gives an opportunity to control conditions and achieve a cleaner burn. We hope our work will lead to clean, compact combined heat and power units.

What's the most far-out application for steam power that we could see?
Probably the research going into steam space propulsion. In the longer term steam could be used as a working fluid for nuclear thermal rockets.



Could steam power space exploration?

A HISTORY OF STEAM

428-347BC Greek philosopher Archytas is believed to have built a steam jet-powered bird, making him inventor of both steam power and the rocket

10-70AD Hero of Alexandria builds the aeolipile, the first steam engine. Steam is pumped into a sphere then out of pipes, making the sphere spin

1712 Thomas Newcomen's atmospheric engine is the first industrial steam engine. It cools steam in a cylinder to suck in a piston

1769 James Watt of Glasgow created the first 'proper' steam engines after experimenting with an atmospheric engine

1769 Nicolas Cugnot builds the first steam-powered vehicle, a cart for transporting the French artillery. The army rejects it as it has to stop every 15 minutes

1774 Claude de Joffroy sails the first successful steam boat on the River Doub, France

"The market for the 5AT itself is small, but the potential for the technology could be much larger"

Dr Alan Fozard 5AT project

expect the vehicle to be fully built and tested within four years and have plans for a freight version designed to haul coal in developing countries.

"The prototype 5AT is intended to be the demonstrator for 'Second Generation Steam' (SGS) locomotives," Dr Alan Fozard of 5AT explains. "Although the market for the 5AT itself is likely to be small, the potential for the technology in general could be much larger."

Up, up and away

That technology is not limited to railways and roads. Steam power is heading somewhere it has only been once before: the sky. In the 1930s, engineers George and William Besler fitted a steam car engine onto a biplane in California. It was just a publicity stunt but the aircraft demonstrated some unusual abilities. The steam plane was so quiet the pilot could call to people on the ground, and its reversible engine made it the first aircraft capable of reverse thrust. The aeronautical press of the time was filled with the possibilities of such propulsion, but Besler never intended to develop the aeroplane further. It was sold to the Japanese government in 1937, never to be heard of again.

Now a new project is looking to take flight in rather a different way. The marvellously named Flying Kettle project carried out the first flight of a steam balloon in 2003 – steam is actually a lighter lift gas than hot air. Flying Kettle eventually hopes to create a steam airship to deliver advertising at skyscraper level or give aerial cameramen the lofty perch they need. And the revival of steam airships could drive the niche market for pleasure cruises in the clouds that hark back to the 1930s heyday of the Zeppelin.

It may sound like an outlandish steam-punk idea, but it could fill a useful niche between hot air balloons, which are too floppy, large, underpowered and slow to fly in any wind above the slightest breath, and helium airships, which are extremely expensive to operate because they must be kept inflated indefinitely.

"With development, a steam airship will be able to arrive from base, deflated and packed in a single vehicle," explains Thomas Goodey of the Flying Kettle project. "It can then be inflated with steam from a boiler carried onboard and flown to the target destination. It will stay there for several hours and return to the launch site to be deflated and repacked."

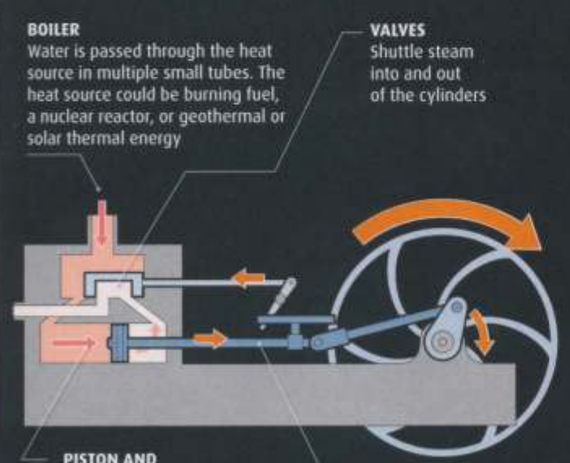
For some researchers, though, steam power could soar much higher than the clouds, and even break through our planet's atmosphere into space. A number of organisations, including British company SSTL, are studying steam thrusters that would help manoeuvre satellites in orbit. SSTL has already tested one, developed in-house in only eight months, on

Nanorobots such as this could in future be powered by steam

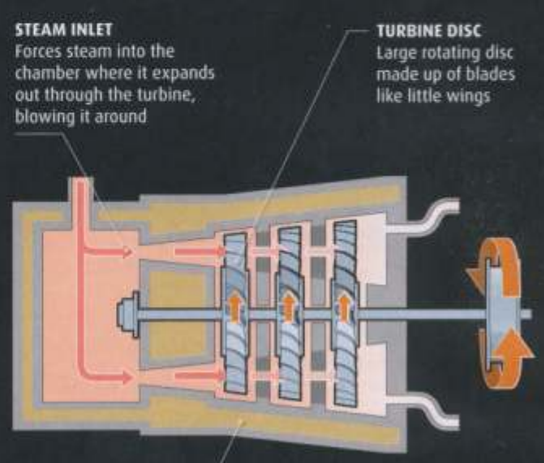
HOW A STEAM ENGINE WORKS

In all steam engines heat is used to turn water into steam at high pressure. The steam is then supplied to the engine itself. Steam engines come in two main families: piston engines and turbines. In piston engines, steam is piped into a cylinder where it expands and pushes on the pistons. Most are double acting, meaning steam is then piped into the other end of the cylinder to push the piston back again. In a steam turbine, jets of steam expand through a stack of fan-like turbines, turning them around to generate power.

Reciprocal piston engine



Steam turbine



TOP GEAR

The Inspiration steam car versus James Bond's *Goldfinger* motor

	INSPIRATION	ASTON MARTIN DBS
Fuel	Liquefied Petroleum Gas	Petrol
Engine	Steam turbine	5.9 litre V12
Power	360bhp/268kw	510bhp/380kw
Size (LxW):	8.5x2m	4.7x1.9m
Speed	200+mph (320+km/h)	191mph (306km/h)
Acceleration 0-60mph	5.44 secs	4.3 secs
Weight	3250kg	1695kg
Power-to-weight ratio	0.082kw/kg	0.224kw/kg

1829 Stephenson's Rocket is selected for the first passenger line, the Liverpool and Manchester railway

1856 Auguste Mouchout constructs the first solar-powered engine, using sunlight to create steam in a glass-enclosed cauldron

1884 Charles Parsons invents the first modern steam turbine. Today, steam turbines generate 86 per cent of our electricity

1906 Fred Marriott sets the world land speed record at 127mph (203km/h) in a Stanley steam car at Daytona Beach, US

1933 George Besler flies the first, and so far only, steam-powered aeroplane as a publicity stunt for his lightweight engines

1938 The Mallard sets the still-standing speed record for steam trains at 126mph (202km/h)

1968 British Rail withdraws steam traction, although some steam trains remain on London transport until 1971

1974 Evel Knievel attempts to jump Snake Canyon with a steam rocket-powered bike. The rocket works, but the parachute fails

New age of steam

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HOW GREEN IS STEAM?

Steam engines offer a number of environmental advantages – and it is these that are driving the current renaissance in steam power. While steam engines remain less energy efficient than internal combustion engines, the way they burn fuel can make them cleaner.

Internal combustion engines burn fuel less 'cleanly' than steam engines

In an internal combustion engine fuel and air are burnt at high pressure and temperature, and the resulting gases then push on the pistons. The conditions within the engine often mean the fuel is not burnt completely and encourage the formation of carbon monoxide and nitrogen oxides. In a steam engine, combustion takes place outside the piston, in a dedicated boiler, before the resulting heat converts water into steam. Combustion occurs at a lower temperature and pressure, leading to a cleaner exhaust emission. Since the fuel is burned separately, steam engines can cope with range of fuels, whether they are biofuels or locally sourced fossil fuels.

It's not all straightforward, however. "External combustion may well offer cleaner exhaust emissions, but if such machinery is burning fossil fuels it is only offering a marginal improvement," warns Paul Johnston of Exeter University's Greenpeace labs. "Biofuels don't necessarily help due to the vast areas of land needed for fuel production. What we really need is to revise how we work, live and travel in the first place."

their UK-DMC satellite. It works by heating water to 200°C with an electric element before passing it out through a conventional rocket nozzle.

"With the steam thruster we set out to see what we could do with the safest possible propellant – water," says Adam Baker, SSTL's business development manager. "Also, we wanted to see how small a system we could build without resorting to exotic techniques; the biggest challenge was making sure we got water vapour and not liquid leaving the nozzle." Baker says the thruster produced less than a millinewton of thrust – but that would be sufficient to power micro-satellites that whizz about in orbit monitoring or repairing larger spacecraft.

Much longer term, the potential for steam edges into what sounds like the realm of science fiction. There are studies afoot for antimatter-fuelled spacecraft that would use steam power to reach Mars in a single stage.

The Steam Tromm Laundry System from LG is already available in shops

The UK-DMC satellite, shown here, uses steam thrusters

Meanwhile, back on Earth, steam power is being put to use in far more than transportation. While it's unlikely that we'll see little puffs of steam coming out of our iPods or mobile phones, steam washing machines are already on sale and German company Enginion is hoping to bring steam into the home. It's combining a building's heat and power in one unit, so your central heating would also generate some of your electricity.

And nanotechnologists at Sandia National Laboratories in Albuquerque, US, have even built steam-powered medical devices that measure less than a 20th of a human hair across. These could be inserted beneath the skin and travel around your body carrying out repairs or dispensing medicine.

Steam power is back – and this time its potential seems limitless. ○

Robin Hague is a former rocket scientist

Additional editing by Ian Taylor

FIND OUT MORE

www.steamcar.co.uk
British Steam Car Challenge

www.5at.co.uk
The new steam-powered locomotive

www.flyingkettle.com
The Flying Kettle steam balloon

1993 Dr J Sniegowski, a physicist at Sandia National Laboratories, creates the first nanoscale steam engine

1999 Steam designer David Wardale establishes the SAT project to produce a new 125mph (201km/h) steam freight train

2003 The Flying Kettle project achieves the first inflation of a steam balloon

2004 Surrey Satellite tests a steam-powered thruster on the UK-DMC satellite

2008 The British Steam Car team intend to set a new world record of 200mph (321km/h) at the Bonneville Salt Flats

2020 Tiny 'silicon chip' steam engines power nanoscale machines

2050 Antimatter rockets with steam-driven propulsion explore the Solar System

ALAMY, SURREY SATELLITE TECHNOLOGY LIMITED, SSI ELECTRONICS, OLIVER BARRYMAN