A system for invention

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Abstract

This paper describes a new System for Invention by looking at existing engineering devices as ingredients that may be combined to create new inventions, it advocates revisiting old problems to see if they can be solved with modern technology and applies the system for invention to produce new inventions. A list of devices is compiled to form a queryable database, which may be extended; lateral thought is encouraged to link these various devices without initial concern over the practicality of the combined devices – the invention outcome to be evaluated subsequently, may be further combined with additional devices to produce supplementary inventions. The essence of a device is discussed, reduction is introduced as a tool for providing a focus on a problem. The system for invention is applied to provide possible solutions to some sustainability problems.

1. Introduction

We are told that necessity is the mother of invention, but it does not always have to be. It is quite possible to put some 'ingredients' together and bake a cake, without the pangs of hunger. Wonderful melodies were produced during the last century; contrived, commercialised, undoubtably they were, but above all they were 'inventive', produced by songwriters who sat down at a piano at 9am and crafted until 5pm using rhythm, diminished sevenths, counterpoint, harmony, unresolved leading notes... to invent new songs. The ingredients used for creating engineering inventions are of course different to those used by a songwriter, engineering ingredients may be: components, sub-systems, principles, devices, effects... henceforth collectively referred to as 'devices'.

The Americans devised brainstorming, where a group of interested parties sits down to solve a problem, the idea is to write down any suggestion - no matter how bizarre - and then classify the suggestions and structure them to see how they may have a bearing on the problem. The technique had limited success in Britain because of 'British reserve', nevertheless the principle of bringing together a group of people and giving them a common

goal, whether it be to build a nuclear bomb, get to the moon, or come up with one good original idea every week, is still valid. As with the nuclear bomb, it is about assembling a critical mass of information.

Solving Fermat's Last Theorem was a task for one brilliant mind (Andrew Wiles, a Brit, working alone for several years inventing new constructions for modern mathematics, financed by America) until the task was completed. History has given us some great two-man-band inventors, including the Brunels, Stevensons, Crick & Watson. History has also shown us that inventors sometimes 'bite off more than they can chew' and when that happens, take much criticism from the media, e.g. Sir Clive Sinclair. Jim Watson is still involved with invention and DNA. Mario Capechi, an ex-student of Jim Watson, now has a DNA-synthesiser (which looks like four coffee machines connected together, each labelled with one of the bases G,C,A,T). By selecting each in a chosen order, a piece of DNA is built; a voltage jump is used to insert the DNA into a cell. Progress in eugenics is staggering - similar to the progress in microprocessors over the past twenty years. Thousands of bright minds are assembled to identify the needs (income streams) and devise new inventions or devices, to satisfy those needs.

With the exception of Dyson, Rolls-Royce and a few other firms, engineering invention in Britain has not been considered a subject worthy of study. Producing, say, a sealed anti-gravity device, is not something that can be achieved without research and building and engineering a prototype. This paper describes a system for coming up with potential inventions only.

Research published recently in Japan shows the world's most fertile and imaginative minds are to be found in Britain, yet in the days before Trevor Baylis created the clockwork radio, whenever he said he was an inventor [Baylis, 2003] he says people would look at him strangely and think "How can I take him seriously?". Had Baylis called himself a designer or an artist he would have been viewed in a totally different way; it is this perception that Baylis hopes to change with the creation of the Trevor Baylis Foundation [www.thetbf.org]. Baylis believes there is an invention in all of us and would like to harness all the wonderful talent in children today by seeing invention introduced into the national curriculum, teaching topics including; systematic approaches to problem solving and how to make prototypes that demonstrate the key features of an invention. The focus is not just aimed at schools however,

one of the authors attended an enthralling university lecture given by Baylis that would have motivated anyone to try and invent something; the TBF hopes to encourage people to come forward with these ideas. The TBF admits that not every invention or idea will make the Inventor a fortune, some may be commercially viable while others may make an important social contribution; the foundation aims to provide help with choosing how best to proceed with an idea and to provide support where necessary.

No work on the subject of invention would be complete without mentioning Leonardo da Vinci (1452-1519), painter, sculptor, engineer, and architect. It may be that his considerable inventive ability was due to the fact that he worked with his hands and brain across a wide range of subjects.

2. Abstraction and naming

The modern motor car incorporates thousands of devices, some large such as the starter-motor, some small such as the transistors in the engine management system. Recent devices added to the motor car include traction-control & GPS.

Dijkstra [1972] tells us there is "an abstraction involved in naming an operation and using it on account of what it does while completely disregarding how it works". Rather than think of an apparatus for mixing petrol vapour with air, we think of a carburettor - its name - derived from 'carburet' which means combining any element with carbon. Abstraction is the key to invention, without it we would get bogged down with verbiage such as 'apparatus for combining petrol with air'.

Searle (1987) tells us that Wittgenstein urged us to think of words as tools, to think of sentences as instruments. It is in the nature of a tool that it can be used for many different tasks. One use for words is that of invention. Bright ideas are usually conceived by thinking with words. The following is one example of the adage: necessity (the problem) is the mother of invention (the solution to the problem).
We've got thousands of tons of nuclear waste encased in concrete, where can we put the waste, so that it will not affect future generations?

We can think about various solutions e.g. store it on the surface, put it underground, drop it in the sea, launch it into space. Each of these solutions has advantages and disadvantages, the last one would be prohibitively expensive at the present time, but perhaps not in fifty years.

Fortunately nature has provided the earth with a wonderful recycling facility by way of plate-tectonics, the device which causes Continental Drift. At the junction of two plates, sometimes the plates are pulled apart and the gap filled with condensed magma, and sometimes the plates are pushed together such that one plate is pushed down below the other - the subduction zone - so that the pushed down plate enters the mantle. If follows that if we drop the concrete encased blocks of nuclear waste on the correct side of such a plate junction, then the nuclear waste will be recycled back into the mantle, eventually in millions of years to be discharged either from volcanoes or at a mid-ocean ridge, by which time the radio-activity will have declined to 'background radiation' level.

The above reasoning is by thinking with words (although some picture forming is involved); the key device (name = plate-tectonics) used to solve the nuclear waste problem has been used on account of what it does (re-cycles the earth's crust). Other subordinate devices are needed, again used for what they do e.g.
nuclear-waste + ship + map + gps + plate-tectonics = recycling

Cooks would think of the left hand side of the above equation as the 'recipe' and the right hand side as the 'meal'. Master-chefs may have a good idea of the flavour they would like to achieve (necessity) and experiment with the ingredients to create that flavour, thereby creating a new meal. Inventive cooks experiment with mixing ingredients which have probably not been mixed before; chocolate-chip-cookies were one such invention.

James Dyson had provided a commercially successful example of necessity (the problem) being the mother of invention (the solution to the problem). The problem being the puzzle of why a short period of hand-washing in warm water provides the same cleaning results as a long period in a washing machine using biological powder and 60°C water. After three years of trying numerous designs, the solution of the Contrarotator (two drums moving in opposite

directions) was found by accident and the problem of manipulating clothes in the same way as a hand-wash solved [Davidson, 2003].

Dyson currently has as many as 20 other household products being worked on in tight security but will not release any of them unless they are truly innovative by solving existing problems in different ways from those that went before.

3. List of devices

A list of devices which a chemist would assemble, would contain all the elements in the periodic table, names of molecules and compounds, catalyst, centrifuge, electron microscopy, precipitation... A list of devices which a geneticist or bio-chemist would assemble would contain that of a chemist plus: bacteria-manufacture, DNA-synthesiser, voltage-jump... A list of devices which a silicon chip designer would assemble would contain some of the devices from the list below e.g. amplifier, clock, gate, oscillator, switch... plus many which are specialised to electronic circuit design. A list of devices is one of the tools of the inventor's trade. The following is a list of devices for engineering, rigour is not possible in such a list. The list may be extended by brainstorming. 'Spinaret' is included in the list as Professor Fritz Vollrath and Dr David Knight have patented an artificial spinaret: Vollrath (2003). Dr Knight tells us "We can use nature's ingenuity to develop new processes and materials with quite exceptional properties in an eco-friendly way". Perhaps a hundred new devices will come from studying nature e.g. the production of electricity by the same method used by the electric eel, the production of light by the same method used by the glow-worm, navigation by the same method used by the racing pigeon e.g. saving the earth's magnetic field data on the outward journey then rerunning the data on the return journey as a control to 'home-in' i.e. nature's GPS.

A abundant-recycled-materials acceleration-deceleration adhesive aerofoil aeroplane aerostat air-flow alloy altimeter amplifier anomalous-expansion Archimedes-principle Archimedes-screw artificial-intelligence atmospheric-pressure atomic-beam-chamber atomic-clock axle

B balance ballcock balloon battery beam bouncing boundary-layer buoyancy buried-refuse

C cable cableway capacitor capillarity carburettor casting catapult cavitation centrifugal-force centrifuge chimney clock clockwork-motor clouds column compass condensation condenser containment contained-liquid continental-drift contraction control corollary crank-shaft current cyclone cylinder

D damping differential-screw displacement diurnal-nocturnal Doppler-effect dot-matrix draught drawing dynamic-absorber

E earth (our planet) economies-of-scale eddy elasticity electrical-generator electrical-motor electrical-resonance electrical-transformer electric-current electrolyte electromagnetic-force electromagnetic-induction electron-microscope electrostatic-condenser emptying-filling electrostatics encasement energy energy-release energy-storage engine engine-management-system engraving etching evaporation expansion explosives

F fabric feedback fence filling-emptying flap-valve flotation fluorescence flywheel focus foundation-block Fourier freeze friction fuel-cell funnel fuzzy-logic

G gate gearbox gearing geometry geothermal geothermal-energy glue governor gps gravity greenhouse guy gyroscope

H hand-tools heat heaters heavy-plant heat-pump hologram hotol-combustion hovercraft hydraulic-damping hydraulic-power hydraulic-resonance hydro-electric hydrometer

I impact impulsive-force incandescence incline inclined-slope inertial-propulsion infrared-radiation inkjet instability intermittent internal-combustion-engine internal-friction inter-stellar-gravity inversion

J jetty jointed-rod

K kinetic-energy

L laser latent-heat lens lever levitation lift light light-waves linear-motor lock lubrication

M magnet magnetic-levitation magnetism mast mathematics mechanics meniscus mercury metal-fatigue microbe microwave mini miniaturisation mirror monomer mould-filling mountain

N Newtonian-mechanics noise non-stick

O one-way one-way-valve oscillator out-of-phase

P parabola perpetual-motion phase-change photo-electric photosensitivity photo-voltaic pier piezo-electric pipe piston pixel plane plasma plastic-concrete plastic-rigid plate-tectonics pneumatics pneumatic-power polarity polarized-light polymer potential-energy power power-tools precipitation prism programming pull pulley pump push

Q quenching

R radar radio radio-control radio-waves rail-track rain recycled-concrete recycled-glass recycled-paper recycled-plastic recycled-masonry recycled-metal recycling reef refraction refrigeration release remote-control repetitive-strain resonance reversal revisiting rigid-plastic robotics rocket rolling rotation rotation-in-space

S sail Salter's-duck satellite sea sea-shore sea-water shaft sharing shave silicon-chip simple-harmonic-motion sine-of-small-angle sinusoidal siphon sky-hook sliding software solar-power solid-liquid-gas sound sound-barrier sound-waves space-shuttle spectrum spinaret spirit-level spring steam-catapult steam-condenser steam-engine storage-retrieval strain-energy structural-profiling suction summer-winter super-conductivity super-plasticiser surface-tension switch swivel

T television thaw thermal-inertia thermochemical thermocouple thermometer three-point-problem tide tidal-current tidal-energy tie tools tower train transformer translation trap tube tuned-damper tuned-mass-damper tunnel turbine turbulence

U ultra-violet uranium

V vacuum valve vibration viscosity vortex-shedding

W wall water-current water-hammer water-waves waves weightlessness welding wheel wind wind-power worm-gear

X X-rays X-ray-crystallography

Y yield yield-stress

Z zone

4. Mixing the devices

There can be few basic inventions, such as the wheel, that have yet to be discovered. Most new inventions are combinations of known devices e.g. Trevor Baylis' clockwork radio is:
clockwork-motor + electrical-generator = radio-battery-replacement

Mixing the devices from the A-Z list, to come up with an invention does not guarantee that the invention will be any good. Britain, more so than America, has many people who will stop poor ideas reaching the market. Coming up with the bouncing bomb idea took one agile mind (Barnes Wallace), getting it to work (or getting it to market) took a good team. Fortunately, Britain has no shortage of good universities which can - with government funding - do the research required for any good idea and then build a prototype.

5. Revisiting

Fifty years ago hundreds of children would have used a Meccano clockwork motor to drive a non-Meccano electric motor (as a generator) to make a 3 volt torch lamp glow for a few seconds; 15 years ago hundreds more children would have performed the same experiment with technical Lego and undoubtedly many more still do. Trevor Baylis' two special contributions were that he revisited the problem when technology had changed beyond recognition, and pursued his idea until he had built a prototype. The lessons are: what may be impractical today may be easily achievable in fifty years time, and build a prototype.

Akio Morita, the Father of Sony, said in an interview quite late in his life, that of which he was most proud was the Sony Walkman. This could not have been built fifty years ago, the Walkman was the first tape recorder which could not be used for recording - it only played pre-recorded music. The Walkman was not only a brilliant invention, it pushed the boundaries of miniaturisation. (In the same interview Akio Morita said "The future is Software, not Hardware".)

Both the Clockwork-radio and the Walkman relied on 'miniaturisation', for this reason 'miniaturisation' is given as a 'device' in the list of devices.

6. Desirable inventions

The following list - extend by brainstorming - may be used to provide the 'necessity' part in 'necessity is the mother of invention'.

Avoidance of waste

Abundant energy from sea water by changing orbits to lower potentials **

Carbon dioxide removal from the atmosphere

Cheap compact personal transport

Cold fusion

Gravity sail

Nuclear fusion

Sealed anti-gravity

Sustainability.

** It is possible that millions of years of solar radiation absorbed by the oceans, have produced some effect in sea water molecules - other than just thermal. Albert Einstein said 'Nature is subtle but not devious', sea water molecules are a subtle place to look for renewable energy, tidal energy being obvious rather than subtle.

7. Putting two devices together

We can innovate by putting two devices together; because we are putting the devices together we use the 'plus' sign meaning 'and'. Often devices are nouns preceded by a qualifier e.g. anomalous-expansion, or stacked-nouns (a favourite of Americans) e.g. water-jack. When a device name is built from several words, we link the words using the minus sign (Germans link words without the minus sign). Some old and new examples of putting two devices together follow:

anomalous-expansion + contained-water = water-jack

buried-refuse + capped-pipe = renewable-energy

catapult + recycled-concrete = sea-defences

explosives + focus = focused-explosion

gyroscope + electromagnetic-force = electromagnetic-gyroscope

gyroscope + impulsive-force = torque-at-right-angles

noise + tuned-sound-damper = silence

plane + light = plane-polarized-light

prism + light = spectrum

recycled masonry + storage-retrieval = hardcore

solar-energy + parabola = solar-furnace

swivel + inclined-gyroscope = torque (classical Victorian experiment)

tuned-damper + light = tuned-light-damper

tuned-damper + mass = tuned-mass-damper

tuned-damper + sound = tuned-sound-damper

uranium + focused-explosion = atomic-bomb

vacuum + shaft = vacuum-shaft

vacuum + tunnel = vacuum-tunnel

water-waves + Salter's-duck = power

wheel + wheel = wheel-within-wheel

We could rewrite the penultimate equation as: power + Salter's-duck = water-waves. Note that this is not an arithmetical rearrangement which would be: power - Salter's-duck = water-waves. Although it would be possible to define '- Salter's-duck' as running Salter's duck backwards, 'less is more' (Mies van der Rohe's credo). In the above equations, the plus sign is used in the sense of 'and', nothing more is implied. The left side of the equation lists the devices, the right side the result; arithmetic cannot be performed. Remembering Wittgenstein's "words are tools"; as with any tool we will use the tool if it helps, but not if it makes the job complicated or difficult.

8. Compounding the devices

Once two devices have been put together to build an invention or give a result (see above) then the new invention/result can be tried with further devices. Few would think of running a large insulated tube up the side of a mountain or cliff in Africa with a wind turbine at the base to provide electricity, yet arbitrarily picking 'mountain' and 'tube' from the list of devices led to:

mountain + tube = chimney

chimney + draught = air-flow

air-flow + wind-turbine + electric-generator = power

Another example:

earth + rotation = centrifugal-force

centrifugal-force + liquid + pipe = free-transport

Again the authors are not saying that either invention is any good, only that they are worth considering because they do not use fossil fuels. It needs an engineer to put numbers to any invention to see if they are practical. The purpose of this paper is to provide a system to stimulate lateral thinking.

Some more examples of potential new devices follow:

aerostat + photo-voltaics + glue = powered-aerostat

powered-aerostat + clouds = weather-engineering

above-cloud-aerostats + photo-voltaics = above-cloud-solar-power

above-cloud-solar-power + hoist + cableway = ten-mile-slide

above-cloud-solar-power + hoist + water + carbon-dioxide = reduction-in-carbon-dioxide

aeroplane + acceleration-deceleration + hoist + release = gently-lowered-equipment

balloon + photo-voltaics + glue = powered-balloon

capillarity + monomer + ultra-violet = waterproofing

car + inversion + ground-effect = upside-down-motoring-in tunnel

diurnal-nocturnal + expansion + contraction + trap = stored-energy

energy storage + translation + rotation = work-done

flywheel + economies-of-scale + renewable-energy = power

mast + wind + vortex-shedding + repetitive-strain = ice-thaw-by-heat

spectrums + rotation + lens + control = light-display

vacuum-shaft + linear-motor + flap-valve = projectile

9. Essence of a device

By inspection of the above it can be seen that devices can be assembled to produce either a new device or an alternative way of constructing an existing device. Generally (this word permeates the whole subject) invention is built from known devices e.g. Dyson's cyclonic carpet cleaner; such devices only win in the market if, as in the case of Dyson, they do a better job. The essence of a Dyson (which is now a generic word like biro) is a cyclone. It is the cyclone that makes the Dyson different to a Hoover. As asserted above, there can be few fundamental devices such as the wheel which have yet to be discovered, invention is likely to come from different assemblies of devices with a new 'essence'. It follows that the essence of Trevor Baylis' radio was a clockwork motor.

The last device in 'Putting two devices together' i.e. wheel-within-wheel, has stability as its essence. Simple gearing ensures that when the outside wheel in contact with the ground rotates at 1 Hertz, the inside wheel (inside the tyre) rotates as say 10 Hertz thus providing lateral stability.

10. Reduction

Reduction is defined as: the process of extracting the essence from a desirable device. As an example, a sealed unit anti-gravity device is desirable, such a device must defeat the principle of conservation of linear momentum, by reasoning we can form a picture of the essence of such a device as being: a device inside a sealed railway carriage on frictionless wheels, which will drive the railway carriage along the track.

Such a reduction does not guarantee that if we can drive a sealed railway carriage with frictionless wheels along a track, we have devised a sealed anti-gravity device. The railway carriage is restrained by its tracks and gravity to movement in only one of the six degrees of freedom in Newtonian space. Nevertheless, the reduction is useful in providing a focus on the

problem, without distractions such as stability. If we can produce a device which will drive our 'sealed railway carriage', it is quite possible that some combinations of the device will provide us with our goal of an anti-gravity device.

By this reduction we can now imagine we are inside a sealed railway, with the carriage at the origin of X,Y,Z axes with the track (and consequently the carriage) pointing in the X direction. If we run forward (accelerate in the X direction), the carriage moves backward along the X-axis, if we slow down and stop (decelerate in the X direction) the carriage stops. The best we can do is to oscillate the carriage. Throwing ourselves against the end of the carriage will not make any difference to the carriage behaviour, though it may to us. We need a device which will provide an impact on the end of the carriage where the energy of the impact has been built up in the Y or Z direction. A gyroscope is worth investigating, for when a rotation is applied about one axis of a rapidly spinning wheel, it causes a torque about an axis at right angles; a second device could be the strange behaviour of particles at the sub-atomic level; a third device could be the piezoelectric effect; a fourth device could be a swing suspended from the carriage roof using inertial-propulsion; a fifth device could be a box which took in electrical energy and did mechanical work without producing heat e.g. an electromagnetic-gyroscope. If the fifth device was achievable, then by the principle of conservation of energy, the work done could be arranged to 'tack' against the earth's magnetic field, thereby moving the railway carriage.

The above example demonstrates that once we start thinking, one idea leads to another, such as if we build a vacuum-tunnel (see 'Putting two devices together') from London to Birmingham, with a slight incline, such that the potential energy lost per mile just overcomes the friction/heat losses of the wheels, then we can start the carriage going at London and let it roll all the way to Birmingham. If the tunnel needs to be too deep at Birmingham, then the tunnel could be given a smaller slope and the carriage given a boost in speed by a linear motor every ten or so miles. Of course the train at Birmingham would have to be lifted to the surface before it was returned to London, and it would be unwise to have passengers in such a system. A more practical system would be to keep the vacuum-tunnel horizontal and restrict the train's contents to freight. We must not be embarrassed about suggesting impractical devices, we should consider all potential inventions.

11. Lateral thought

As an example of the encouragement of lateral thought, suppose we start with 'amplifier' as one device. The essence of an amplifier is its ability to increase or decrease something; obvious examples of the 'something' being: electrical current, light, sound... Remembering the premise of brainstorming, let us not be concerned at this stage with the practicality of linking the component devices, only that each pairing may be worth considering. Obviously 'amplifier + glue' is not worth considering, or is it? To the right of the first three pairings, lateral-thoughts are shown, it is left to the reader to think laterally for the remaining pairings. If no thoughts are forthcoming, it may be that the pairing is not worth further consideration.

amplifier + crank-shaft	eccentric cranks, variable cylinder strokes
amplifier + damping	tuned-damping, tuned to a race-track
amplifier + evaporation	increasing air moisture, humidity control
amplifier + gravity	
amplifier + greenhouse	
amplifier + hologram	
amplifier + kinetic-energy	
amplifier + lubrication	
amplifier + piezo-electric	
amplifier + pneumatics	
amplifier + precipitation	
amplifier + refraction	
amplifier + sail	
amplifier + siphon	
amplifier + sliding	
amplifier + solar-energy	
amplifier + spring	
amplifier + strain-energy	
amplifier + suction	
amplifier + thaw	
amplifier + thermal-inertia	
amplifier + thermochemical	
amplifier + thermometer	

amplifier + tide
amplifier + vibration
amplifier + viscosity
amplifier + vortex-shedding
amplifier + water-current
amplifier + water-hammer
amplifier + wheel
amplifier + wind

12. Querying the database of devices

Querying any database can be made automatic, it is simple to write a program to put devices together and to print out a long list of possible inventions. Whether the invention turns out to be sensible can only be decided by a quorum of humans. Even after approval by a quorum, it may be that there is no market for the invention.

Writing a program to put devices together is worth consideration. If the program was unintelligent, then it would throw up too many combinations for consideration. As an example, an unintelligent program would, along with millions of other combinations include the first two devices starting with 's' in the list of devices, i.e. sail + Salter's-duck.

The essence of a sail is the aerofoil shape which gives a pressure difference in a current of air and thus moves the object to which the sail is attached. The essence of Salter's-duck is the conversion of a rocking motion to electrical power. The attachment of a sail to Salter's duck would not be useful, but as the computer would not know the essence of each device and even if it did would not be able to weave the train of thought of an engineer, then 'sail + Salter's-duck' would be added to the list. To avoid 'sail + Salter's-duck' being added to a computer produced list, each device would need to be associated with a set of attributes (or keywords) which would filter out incompatible pairings.

Producing and maintaining a list of attributes for each device would be straightforward for some of the devices, but difficult for a significant proportion. As an example 'microbes' are

the engineers of the planet, microbes have been the active ingredients of geological change and are thus listed as a device. Cave microbes have formed great caves by eating rock, and in the absence of light have provided a food chain for small fish and crustacea. Writing a set of attributes for 'microbes' such that the computer could meaningfully match the attributes with those of other engineering devices would not be straightforward, but would be worthwhile.

A word-search through a list of devices or proposed combinations of devices, has been found to be useful for pairing devices. Every text-editor or word processor has facilities for a word-search. The way of proceeding at the present time, is to have an engineer try devices together, using a text editor for a word search where useful.

Any search engine on the Internet may be used to type in a selection of devices from the list of devices. The results of the search may or may not be useful. Generally references which include all the words in the query are displayed at the beginning of the list of documents.

13. Sustainability

"Sustainability is the issue, all others are of secondary importance" [Porritt, 1998], so sustainability would be a good subject for testing the system. Briefly 'sustainability' is the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs [Brundtland et al., 1987]. Factor Four - Doubling wealth, halving resource use - [Weizsäcker et al., 1997] is the latest report to The Club of Rome (an international group of environmentalists) and describes a new form of progress 'resource productivity'. Factor Four, in a nutshell, means that resource productivity can - and should - grow fourfold. [Weizsäcker et al. 1997] use 'Consumption' (tuberculosis) as a metaphor for the inefficient use of our resources (which they call the wasting disease) and tell us "The cure for the wasting disease comes from the laboratories, workbenches and production lines of skilled scientists and technologists, from the policies and designs of city planners and architects, from the ingenuity of engineers, chemists and farmers, and from the intelligence of every person.

The system for invention was used to produce the following twenty inventions, with the aim of either saving energy or time i.e. part of the Government's sustainability initiative. Each invention is followed by background information.

(1) heat-pump + sea + air = power

Heat pumps have been around for over a century and rely on infinite supplies of fluid at two different temperatures. There are few places where such supplies are available. One is the coast where for 250 days per year the sea temperature is more than 10° Centigrade different to the prevailing wind, another is at the middle of the deep oceans where water temperature at the bottom of the ocean is constant at 4°C. Marine turbines are being assessed for providing renewable-energy for Britain; as with nuclear energy, whole life cycle costs may be far in excess of those expected. Heat pumps have few moving parts and would be mounted on the shore, therefore maintenance is likely to be much less than that for marine turbines.

(2) recycled-glass + photo-voltaics = cheaper-solar-panels

Many square miles of double glazing fail each year and are crushed. A significant cost component of solar panels is the glass casing. Recycled double glazing units may make suitable casings.

(3) renewable-energy + storage-radiator + switch = daytime-top-up

Few in the UK have not heard of Economy 7, a tariff which is principally used for charging night storage radiators between 11-30 pm and 6-30am, when electricity usage is low. Switching on and off is automatic. Instead of switching off, it is trivial to switch to another electrical circuit containing low voltage renewable energy. This would enable consumer purchased renewable energy sources to trickle feed night storage radiators for the other 17 hours of the day.

(4) aerostat + wind-turbine + generator = renewable-energy

Wind increases greatly the higher we go, modern piling techniques (or mass readymixed concrete) make anchoring an aerostat (lighter than air balloon) cheap. A wind turbine could be mounted beneath an aerostat, and the electrical energy generated run down a cable attached to the tether. The aerostat would be winched in to service the turbine.

(5) aerostat + vortex-shedding + Salter's-duck = renewable-energy

Less efficient than (4), but more robust would be to use a lopsided aerostat to induce vortex shedding thereby causing the aerostat to dance, thus providing 'tugs' at ground level where the tug energy could be converted to electrical energy using Salter's-duck.

(6) renewable-energy + economies-of-scale = energy-storage

For low cost electrical energy storage, 30m diameter concrete tanks, similar to those used in sewage filtration treatment, could be filled with salt water and 100-200 crushed car bodies connected in series to make a huge electrical battery.

(7) renewable-energy + flywheel = energy-storage

Tidal energy is intermittent, a traditional method of storing peak tidal energy to fill in the energy troughs, has been to pump water to a higher level during peak energy production, thus storing potential energy, then recovering that potential energy via water turbines driving electric generators; unfortunately the efficiency of the cycle is not high. A higher cycle efficiency for energy storage and recovery could be provided by typically 30m diameter flywheels, until recently too expensive. Now that almost 100% of steel is being recycled, the world has excess steel making capacity, and modern electronic instrumentation has provided the ability to manufacture large accurate bearings, and to balance cheap cast in-situ reinforced concrete flywheels lying in a horizontal plane i.e. spinning about a vertical axis.

(8) tar-sands + underground-combustion = energy

We are told that North America's tar sands could provide enough energy for a millennium, unfortunately the oil extraction process consumes 95% of the energy available. Britain has given up deep mining because of the cost of cutting the coal and bringing it to the surface. The standard method of putting out a fire is to starve the source from oxygen. Civil engineers now have machines which can sink cheap shafts and bore between them. If the 'heading' was through a coal seam or tar-sand, a fire within that seam could be controlled by the amount of air pumped down one shaft (cf. nuclear energy production is controlled by raising and lowering the rods) and using the hot air from the exhaust shaft to generate electricity by steam turbines. Obvious attractions are: health saving, energy saving as the fuel does not need to be lifted to the surface, energy and environmental savings as the mountains of slag produced by deep mining are completely eliminated.

(9) marine-debris + ship + map + gps + plate-tectonics = recycling

Much public debate continues on what to do with old oil platforms and other marine debris. The creators have provided a solution via plate-tectonics. Several places in the mid-atlantic, provide conditions at sea where one plate is continually pushed down below the adjacent plate, thus an old oil platform could be sent into the mantle (see also Abstraction and naming).

(10) tuned-mast + wind + Salter's-duck = energy

Visitors to the seaside on a windy day will see swaying flag poles on the prom. By varying the mast stiffness within its length it is possible to tune the mast so that the top of it sways for a very wide range of wind speeds. If a beefed up device of the type used in watches to generate electrical energy when the arm swings, was completely sealed within the top of the mast, then it could provide a source of low voltage electricity e.g. for remote weather stations to transmit wind speed and other weather data.

(11) movement + Salter's-duck + radio-waves = no-cabling-required

The train failure on the London underground recently highlighted a difference between the information available to a pilot and a train driver. A pilot has many dials telling him the state of his engines and just about everything else; as railway carriages need to be coupled and decoupled, cabling similar to that used in aeroplanes is not practical. Added devices which generate electricity by movement could be used to send radio information to the cab, giving carriage behaviour including axle bearings, performance of electric motors and the like, while the train was moving if it was above ground, or at each station in the case of an underground train if electrical interference was too high when the train was in a tunnel. The problems with the introduction of high tech trains in this country have been well aired by the media; the device described, would allow piecemeal improved control systems to be added. It is reasonable to assume thousands of such devices would be needed of perhaps a dozen standard designs, when one fails, a replacement would be bolted on, i.e. no-cabling-required.

(12) heat + thermocouple = electrical energy

Although wood is scarce in some parts of Africa, it is still the basic fuel for cooking, thus heat is available on a daily basis. As an alternative to Trevor Baylis' clockwork device for generating electricity, thermocouples generate electricity directly - without any moving parts. They are used to measure the very high temperatures in the jet engines of aeroplanes and

therefore have proven reliability. A walking stick for the village Chief (or any other device using the thermocouple effect), could have its point in the cooking fire with the handle containing the bundle of alternate junctions maintained at ambient temperature. Generated electrical energy would be stored in a battery. Six volt pocket televisions could provide educational information via satellites to the remotest parts of Africa using batteries charged by thermocouples.

(13) sea-water + diurnal-nocturnal + greenhouse + condensation = desalination

The Arab states in North Africa have supplies of oil, thus freshwater can be obtained from seawater using traditional desalination plants. Much of Africa does not have oil and a low-tech method of desalination would be useful. Day and night temperature differences are high near the equator, thus a few acres of glass (or clear plastic) cloches - near to the sea - could use the greenhouse effect to desalinate sea water by condensation, the freshwater being collected in cheap plastic gutters laid-to-fall running along the ground.

(14) drone + focused-waves + gps + camera = surveillance

Remote controlled spotter planes need to carry their own fuel and thus have to land at regular intervals for refuelling. Although radio waves transmit sufficient energy to send a signal, the amount of energy transmitted is insufficient to power even a small model aeroplane. A ground-station could produce a beam of focused-waves, the station could receive positional information from the spotter plane and thereby cause the beam to track the plane and thus be able to transmit energy to keep it flying.

(15) instability + silicon-chips + electromagnetism + gyroscope = stability

wheel-within-wheel + stability = stable-monocycle

Modern electronic control systems allow aeroplanes to be flown at speeds at which they are aeronautically unstable. A powered monocycle using gyroscopic stabilisation could provide cheap travel, furthermore the compactness of the single wheel design means that a battery powered version of the monocycle could be taken into the office during the day and kept under a desk while it was being recharged from a standard 13 amp socket.

(16) monorail + power + seat = pedestrian-monorail

An electric motor, working at 110 volts for safety, would easily pull a pedestrian along an overhead rail at seven mph. The pedestrian would be seated below the rail with the power

unit hooked on the rail above, thus ensuring a very stable ride. To change rails would require that the pedestrian unhooked, and supporting the unit on his/her shoulder walked to another rail and hooked on again. The civil engineering needed for the pedestrian monorail would be cheap, as both the main components i.e. readymixed concrete and structural steelwork, are cheap.

(17) material + structural-profiling + pump = inflatable-wind-engine

Those who have sat in a modern Lifesaver's inflatable know just how rigid an inflatable structure can be made using modern materials. A significant percentage of the cost of construction of wind farms is for transport and plant for the erection of the masts and blades, the wind farms usually being in remote areas. At a domestic level, it is possible to make both blades and mast as 'inflatables' that can be packed into separate crates (a third crate containing the generator) and delivered to site by a van. Erection would be by manhandling i.e. bolting the mast base-ring to a mass concrete base, bolting the mast top ring to the blade bearing ring and the generator ring, inflating the blades, inflating the mast causing the blades and turbine to be lifted into place.

(18) shaft + air-current + summer-heat-storage = renewable-energy

Civil engineers routinely form large diameter, rotary bored holes in the ground for piles of diameters 600mm to 2400mm, and lengths up to 60m. Such holes can be formed as close as 300mm to the edge of existing buildings. The technique is ideally suited to boring in dry cohesive materials such as London Clay (where underreams can be formed), however it can also be used in all ground conditions if casings are used to support the sides of the hole during boring. Soil is good for heat/cold storage; the permafrost beneath the Nine Elms cold store in London extends to a depth of 30ft and will likely take 100 years to thaw after the cold store is shut down, thus soil can be used to act as a summer heat storage system. After a hole for a heat storage system is bored, the bottom 300mm of the hole would be filled with sand (to act as a soakaway for condensate) and three U shaped pipes (one working and two standby - each with a condensate weep hole at its base) would be lowered into the hole before the excavated soil was returned to the hole. If for the prevailing wind direction, the inlet to one side of each pipe is positioned on the windward side of a building, the exit on the leeward side, then the heat from warm summer air will circulate down to the bottom of the U pipe and up the other side, giving up some of its heat to the ground. Cold air is more dense than hot air, so the air flow through such a system may need a fan. The opening and closing

of simple flaps would permit cool air to be brought into a building in the summer & pre-warmed air in the winter, for topping up to room temperature.

(19) site-ps (positioning system) + pen = site-pen

Much time is wasted by site engineers when their setting out profile boards are accidentally knocked by construction plant. If the initial setting out established stations on the site where no plant could ever go, then electronic solution of the three-point-problem could provide a site positioning system with an accuracy of 1mm i.e. within most construction tolerances (cf. 600mm by gps). A site-pen using the site-ps could display X, Y & Z coordinates in space for the point of the pen.

(20) site-ps + excavator = robotically-controlled-excavation

Although human control of excavators is ideal for small construction sites, open-cast mining and excavation in polluted sites may benefit from robotically-controlled-excavation.

14. Conclusions

The system for invention has been used to link together engineering devices to produce twenty possible new inventions. Although the authors believe that the inventions presented are novel, they make no claims that the inventions are either novel or practical. The inventions given are no more than examples to encourage young engineers to try the system for themselves.

Professor Iain MacLeod [MacLeod,1998] who has been engaged in expert systems and innovation for the past twenty years, now runs a postgraduate class entitled "Innovative Design in Structural Engineering" at the University of Strathclyde, and will be making a System of Invention available to his students. He says:

"We are now trying to get our students to think creatively but it is an uphill struggle. Education tends to lead them to the attitude - 'Tell me what you want me to do and I will do it'. This is not the fault of the students themselves but of the fundamental philosophy of learning that we promote which, in my opinion, results in outcomes that are significantly sub-optimal. But we do not know what an optimal process for education would be since it would be different for different people."

The authors hope that a System for Invention will provide a mechanism for encouraging creative thought for some people.

15. References

BAYLIS T. (2003) “Patently Obvious” Daily Telegraph - June 21st 2003, London

BRUNDTLAND G. H. et al. (1987) "Our Common Future, the final report of the World Commission on Environment and Development" which led to the United Nations Earth Summit in Rio de Janeiro, 1992.

DAVIDSON A. (2003) “Gold Dust” The Sunday Times Magazine - June 29th 2003, London.

DIJKSTRA E.W., DAHL 0.J., HOARE C.A.R., (1972) "Structured Programming" Academic Press, London and New York.

MacLEOD I.A., KUMAR B., McCULLOUGH J. (1998) “Innovative design in the construction industry” Civil Engineering – Paper 11180, London.

PORRITT J. (1998) "Engineering a sustainable future - report on the 20th Maitland Lecture" Journal of the Institution of Structural Engineers, London.

SEARLE J. (1987) "The Great Philosophers" in conversation with Bryan Magee about Wittgenstein's philosophy, BBC Books, London.

VOLLRATH F, KNIGHT D, (2003) "The Daily Telegraph", April 5.

WEIZSÄCKER E.V., LOVINS A.B, LOVINS L.H. (1997) "Factor Four - Doubling wealth, halving resource use - the new report to the Club of Rome" Earthscan Publications Ltd, London.

New inventions are being made every day, but not all of them are great. Only a select few are remarkable and actually change the world. With that said, here are 100 inventors and their invention ideas that shaped the future.Â That being said, it doesnâ€™t mean the inventors who came before were any less relevant. Inventors came up with brilliant gadgets, equipment, tools, and machines that we still use today, while others opened the doors for future generations to develop and improve. What follows is a collection of 100 famous inventors and their best invention ideas. 1. Cro-Magnon. Before humans, an early generation of people called Cro-Magnon demonstrated outstanding talent to create tools to help sustain an ancient way of life. An invention can be thought of as a new product, system, or process that has never existed before and is created by study and experimenta-tion. Innovation refers to an. improvement of an existing techno-logical product, system, or method of doing something.Â â€¢ The Young Inventors Program (YIP), established in 1986, is a statewide program coordinated by the Academy of Applied Science and a volunteer consor-tium of New Hampshire educators developed to spark creativity in students in Grades K through 8. YIP combines teacher training with the integration of invention into the classroom curriculum, and hosts an annual celebration for student inventors. Contribute to the App Inventor system or educational resources. Learn More. Collaborate. Learn about research and affiliations with App Inventor. Explore Options. Artificial Intelligence with App Inventor New Curriculum and Teacher Resources. Try our App Building Guides for the Youth Mobile Power Series. Made in partnership with YR Media. News & Events. Digital Learning Diaries to document first steps of coding using MIT App Inventor. More. Changes in the new MIT App Inventor Gallery.Â The New MIT App Inventor Gallery will go live this coming weekend. During the weekend there will be a brief period where the Gallery will be unavailable while its projects are moved to the new Gallery. More. New Zealand Teachers All in for App Inventor. More. View More. Mary Bellis covered inventions and inventors for ThoughtCo for 18 years. She is known for her independent films and documentaries, including one about Alexander Graham Bell. our editorial process.Â "F" Is for Inventions Ranging From Frisbees to Firearms. Dogs around the world are grateful for the invention of the frisbee. Getty Images/Elizabeth W. Kearley. FABRICS.Â Signaling System (Pyrotechnic). Martha Coston invented a system of maritime signal flares. Skyscrapers. The skyscraper like many other architectural forms, evolved over a long period of time.