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A CASE FOR GENERAL PUBLIC CONTRIBUTION, AWARENESS, AND "THE ZERO GRAVITY OVEN"

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Abstract

The Zero Gravity Oven, a by-product of collaboration between a diverse group of people. The paper attempts by using the creation of the zero gravity oven as a symbolic model to discover the reasons for its existence and how the mechanism of this interaction of diversity can be expanded globally to encourage interactions between the scientific community and the general public for the enhancement of space awareness in the masses.The paper also discusses general problems of cooking in space, and also describes the proposed design for a space based oven. The oven attempts to overcome potential problems encountered in the cooking of conventional food stuffs due to the absence of gravity, and its effects on the cooking processes, included are the outlined construction details for a prototype model, which we hope might be used on the NASA Space Shuttle or the Space Station sometime in the future, in some small way improving the quality of life for the future astronauts by allowing them to enjoy some good old fashioned cooking instead of the reheated and rehydrated food they currently use. This may also be a great psychological benefit on long duration trips to Mars, for example.

1. Introduction

*"Earth is the cradle of Mankind, but one cannot live in a cradle forever." (Konstantin Tsiolkovsky, (pre-revolution) Russia*The Zero Gravity Oven is symbolic of a coalescence of diverse people - a dairy farmer, physics graduates, a carpet cleaner and a salesman, all with varying educational and social backgrounds, when brought together to view the launch of a Space Shuttle.
The Shuttle launch was a focal point in the evolution of humankind, the keyhole to the abundance of the universe, not just for the fireworks display of a billion candlepower energy release, but to this day and this small area of our planet where just a flicker of our once global aspirations to explore and gain knowledge of the universe still exists. A monolith, if you wish, only this can bring together such a diverse group of people when in normal circumstances the exchange of ideas would not occur.

The paper also discusses the certainty of the rightness of the enterprise, a burning brand taken from the Promethean fires, and its potential mechanisms to create public awareness from the symbolic "Space Cake" to Space Station.

2.Background

The are a number of barriers to the cross-over between the realms of everyday life and "what might be". Amongst these are education, social opinion, including the general negative view of science and engineering in many countries, and, perhaps as a consequence, the typical inability of the scientific community to find common ground with the general public. These problems lead to introspection, with society turning inwards in search of security and safety, and a consequent loss of funding for programs that seek instead to open new horizons, with new challenges to face. We have forgotten that life is dynamic, and that in many senses humanity is the Earth's way of reproducing itself.

We also have to deal with the social constraints that seek to deny the spirit generated by the realisation of our destiny, in favour of economic, political and military advantage, for example the closing down of the Apollo Program and all future manned Moon exploration within five years of the Apollo 11 Lunar Landing

2.1 Looking to the future

Potentially, the result of large-scale travel into space could be the removal of the blinkers that hide our capabilities and destiny from ourselves, an inherent destiny born from the early existence of DNA and its inherent survival and reproduction mechanisms. Few people fully understand these mechanisms, but they exist in everyone, perceived as a spirit of adventure, learning and survival in varying orders of magnitude, but for one moment (man's first tentative steps on the Moon) that indescribable spirit awakened in the masses. This is a key mechanism towards achieving global awareness of our destiny, though paradoxically the desire to survive can also appear as the desire for safety that we previously mentioned.

Evidence of this spirit exists throughout history, one of the most recent examples being the Wright Brothers, who built their first aeroplane and flew it at considerable risk, using technology that was barely capable of the feat. Social constraints of the period convinced the masses that it would be inconceivable for them to afford such an experience, and yet today, after ninety years of further experimentation and engineering, we practically use planes like buses.

Today, we have achieved the first few flights into orbit and to the Moon, but even with the benefit of the great abundance of space technology, the social constraints are so immense that budgets are being reduced, eliminated or held constant. We feel that this is largely due to the inability of the scientific community to capture the imagination of the general public by offering the experience of space flight to everyone, rather than just the lucky few.

NASA attempted to support this goal with their Payload Specialist and "Citizen in Space" programs on the early Shuttle flights, but that ended with the deaths of Christa McAuliffe and Gregory Jarvis on Challenger's last flight, STS 51-L. Perhaps, as has been claimed, the current Shuttle design is too dangerous for public space flight to continue, but we feel that to generate and sustain funding for it successor, we must make serious efforts to ensure that it meets the required cost and safety criteria so that we can not only restart public participation, but greatly expand it.

2.2 Expanding The Bubble Of Enthusiasm

Start an approachable ("Glossy") organisation like the IAF, but at a level which allows normal people to join and understand, and offer a focus for the space-related industries to draw the outline of the future public space transportation systems with the effect of removing the blinkers of constraint and awakening the untapped potential of the human spirit, a global interface of diverse sections of the public, an exchange of thoughts and ideas (a large scale model of the symbolic "Space Cake" concept).

Currently there are numerous space organisations and societies around the world, but they are fragmented. Perhaps it is time for a global solution.

2.3 A World Space Organisation

It is generally considered that the lack of coverage of Space Shuttle launches is due to the increasing disinterest in the public at large with the manned space program. For example, 'Why spend my tax dollars for a few highly- trained people to experience something I cannot ?' Claims of space 'Spin-Offs' have been used to attempt to justify the cost of space flight and to encourage public interest, but to little avail. At the same time, a number of projects that are expected to result in the desired reduction in launch costs and increased safety and reliability, such as the Delta Clipper, Hotol, Skylon, have been put forward, but none have been able to raise the full development funding required from commerce or government.

This leads to the idea of a World Space Organisation, one of global proportions where every country contributes an equal percentage of their GNP, and in return receives the same amount back in terms of work on the development of a larger space station than is currently being proposed, big enough to accommodate significant public involvement, and the development of a cheap, safe and reliable public space transportation system to take people and materials to and from the space station. A fair distribution of cost in this fashion would not cause unfair financial disadvantages to any one country, and could release untapped resources and manpower.

2.4. Introduction To The Zero Gravity Oven

The remainder of this paper is devoted to the "Zero-Gravity Oven", as a symbol of what can be achieved by a diverse group of people, and an example of the innovative cross-fertilisation that is needed. In the end, the concepts behind the design will bring forth humanity's common goals for unity and growth.

> *"I think that the more space becomes available to the general public, the more support the public will give. President Kennedy achieved this support, and in you and everyone I believe that we can rekindle this spirit for all mankind. In hope may conflict over borders be forgot, and hold their peace to unite in a common goal in what must be our destiny where the universe holds no boundaries."*

-- John Nicholson (Urban Man), from letter to US President Bill Clinton, May 1994

3. The Zero Gravity Oven

It is reported that cooking in a zero gravity environment is problematical. Currently food preparation in such environments such as on board the NASA space shuttle is limited to re-hydration and heating of precooked foods.

3.1 Brief

Investigate potential problems of zero gravity cooking and design an oven capable of cooking a simple sponge cake that would overcome these problems. The design must be small, simple, energy efficient and capable of simple operation in the zero gravity environment.

3.2 Investigation

This section attempts to analyse the potential problems that could cause cooking in a zero gravity environment to be difficult. In the absence of hard facts much of this is based on purely hypothetical guess work though hopefully most of the main issues have been covered.

3.3 Bulk behaviour

In a zero gravity environment there will be no unidirectional force to cause the cooked food to amalgamate or collect in one particular place. Astronauts have often been seen demonstrating how fluids in space form free floating globules. While surface tension will cause some (if not all) fluid globules to coalesce into larger ones this process (if it occurs at all) would need to be encouraged. Similarly a powder or dry constituent would probably be even harder to cope with since it would have almost no cohesive forces to bind it.

For certain foods, and in particular a cake, it is important that the constituents are brought together, mixed, formed into a shape and then cooked in a controlled manner to achieve a reasonable result. For all of these the bulk behaviour is crucial.

3.5 Bulk mixing

The bulk behaviour of the food being cooked is important for even cooking. Quite apart from the thermal processes involved (see 3.3) the constituents of a recipe need to be mixed effectively and this will only occur when the mass is brought together and mixed as a whole. It would be difficult to achieve an even distribution of components if they were to remain separated for the most part in localised packets or globules.

One mixing problem eliminated by an absence of gravity would be that of denser items sinking to the bottom of a mixture. This for instance puts limits on how slowly a cake containing fruit can be cooked without all the fruit collecting at the bottom! Also there would be no "floating" of lighter liquids such as oil over others - presumably an emulsion would form. With no gravity, matter of different densities will experience an equal force per unit volume - none at all.

3.6 Convection and mixing

Heat transfer occurs by three main processes : radiation, conduction and convection. Of these convection would not occur in a true zero gravity environment since it relies on warmer and hence less dense fluid rising over colder, more dense fluid and initiating convection currents that cause distribution of heat. Hot soup rises from the bottom of the pan, water bubbles vigorously when it boils and the top of an oven gets hotter than the bottom - all these are examples of convection.

Strong convection may be sufficient to keep a cooking mixture evenly mixed. This would normally be true of low viscosity fluids, for others convection would play little part in mixing. It is assumed that the flow of cake mixture due to convection during its cooking time is likely to be low and hence not contribute to any mixing required for even constituency or cooking.

3.7 Heating

Often convection currents will cause sufficient thermal stirring during cooking keeping the substance evenly mixed and hence evenly heated. However if the heating is too vigorous or the fluid too viscous then localised overheating (or burning) could occur. Obviously the lack of any convection at all will require new means to ensure even distribution of heat. Apart from convection it seems that conductive and radiative thermal transfer processes would be unaffected by an absence of gravity. A mixture cooked slowly at a low temperature, perhaps by a microwave or radio frequency cooker could therefore be heated largely unaffected by the absence of gravity.

3.8 Energy constraints

Constraints encountered in a space environment would undoubtedly limit the amount of power available so energy efficiency would need to be a primary concern for the design. Also the space environment would most likely render some means of supplying heat totally unsuitable - baking a cake using a combustion process (a gas cooker) would not only be a safety hazard but also unlikely to work due the manner in which a naked flame behaves in zero-gravity.

3.9 Bulk constraints

Weight and size of a space payload is usually at a premium and hence a cooker not well adapted to these constraints could not be considered. Heavy construction materials and excess internal volume would have to be kept to a minimum.

3.10 Operational constraints

Due to the extreme difficulty in handling loose substances in space careful thought must be given as to how food will be prepared and then cooked without contaminating the space shuttle environment with debris. This should be done without placing too greater restrictions on the range of foods that could be prepared. Also it must be remembered that an astronauts time is a valuable commodity and to be practicable food preparation must not consume too much of it.

3.11 Safety

A primary issue in a space environment is that of safety. Any potential solution must ensure that an astronaut can prepare and cook food without risk of burning, fire, atmospheric contamination or electrical accident. Even a simple thing like the contamination of the space shuttle air supply with unpleasant cooking aromas could point to a potentially serious risk - if food accidentally burnt the smoke could rapidly cause considerable problems.

4. Solutions

This section presents various solutions to the problems identified in the investigation. Not all are feasible and not all are practical for the proposed cake cooker. See section 5 for the specific solutions to be used in the cake cooker.

4.1 Bulk behaviour - solutions

For many foods a high degree of pre-preparation could be used to overcome the bulk behaviour problems (as is done now) but for fresh cooked products and longer missions the problems would have to be addressed. Presumably astronauts will eventually tire of easy to manage boil in the bag meals and pastes however nutritious!

An obvious solution might be to provide some "artificial" gravity to force the cooked substance (which may not be very fluid at all) together in a confined container. Another might be to stir the substance (possibly with a suitable gelling agent) to encourage mixing and coalescence. For less stirrable substances simple confinement to a suitable container such as a sealed plastic bag with little or no air might be more appropriate.

4.2 Bulk mixing - solutions

Unless the mixing process is largely driven by convection and convection can be recreated then some kind of external mixing will need to be supplied. The most logical solution would be to emulate that supplied in normal cooking, i.e. stirring. Stirring can be provided in many ways, some which might conflict with other constraints.

For a low viscosity fluid it is possible to use a magnetic stirrer with no mechanical linkage, a magnetic bar inside the fluid container being rotated by an external rotated magnetic field. Another solution is mechanically driven paddles or vanes in the container, these might also aid coalescence (see 4.1) .

4.3 Convection and mixing - solutions

It seems likely that for many foods an absence of thermal convection to rapidly carry away localised heat will be a major problem with cooking in zero-gravity. Only two solutions seem feasible: one is to provide continuous and vigorous stirring, the other is to try to reintroduce convection by introducing an artificial gravity; i.e. rotational acceleration.

4.4 Heating - solutions

Possible heating methods include electrical (direct and indirect), hot fluid circulation and microwave/radio-frequency devices. A microwave (or R.F.) cooker is now a common piece of household equipment in any modern kitchen. It has many advantages over a conventional oven giving rapid delivery of heat directly into the cooked food caused by absorption of electromagnetic energy by water in the food. This means short cooking times and high efficiency since a large mass of cooker does not have to be warmed up to the cooking temperature. However the rapid cooking, and internal delivery of heat can cause problems with overheating especially for liquids that require frequent stirring. Also foods with low water content will not cook effectively in a microwave.

Any heating method using indirect heating must rely on efficient circulation of an intermediate medium. For instance to heat food for cooking by an electrical element it could either be immersed directly into the food, as in a kettle, or heat the air surrounding it as in a conventional oven. In the latter case the air would require forced circulation to ensure even distribution of heat in the absence of convection. The air circulating could equally well be heated by superheated steam or some other hot fluid which it comes into indirect contact within a heat exchanger. Using a heat exchanger would increase the isolation between the heat source and any combustible materials being cooked (see 4.8, Safety).

4.5 Energy constraints - solutions

It is not known what the power restrictions might be. However it is known that for a space shuttle flown experiment 500W is a typical maximum power constraint. This would pretty much limit the scope of heating to a small microwave device or small electrical oven. Cooking a 15lb turkey for Thanksgiving is pretty much out of the question (and pointless) but small cakes and quantities of liquids would definitely still be possible.

4.6 Bulk constraints - solutions

Space is always at a premium in space, as is weight. Again it is not known what the cost for delivery into orbit per pound of payload is but it will certainly be much greater than $1,000, probably closer to $10,000. This will mean that excess bulk and heavy materials will have to be minimised to reduce cost. The main constituents of a cooker would include the inner and out containers, insulation, heating device(s), heat circulation equipment, stirring equipment and safety equipment.

4.7 Operational constraints - solutions

Unless a microwave type of device were used there does not seem to be any way to provide easy access to the cooking food and hence this would eliminate kinds of cooking requiring manual intervention. Even with a microwave access requires shutting off of power with subsequent rapid heat loss so this is not ideal. Perhaps some remote arm could be incorporated but this seems a little excessive for something that is supposed to be simple. Fortunately for many kinds of food (in particular cakes) this kind of intervention is not required so all is not lost. When removing food from the oven a negative gradient could be used to prevent any loose particulates from being removed as well. A slight suction would be turned on, the oven opened and the cake removed.

For a low food delivery time a fast cooking time is required - a microwave oven delivers the thermal energy very efficiently and hence gives such a fast cooking time. Also as many food stuffs could be provided in a pre-mixed or partially prepared state (obviously not already cooked as this would defeat the point of home cooked space food!)

4.8 Safety - solutions

Most of the safety issues would seem to be addressable by ensuring the heated volume is effectively isolated from the space environment. This includes thermal, physical and electrically isolation.

Thermal isolation can be achieved by minimising the thermal transfer processes. A very low thermal conductivity insulator could surround the cooking volume or perhaps even a vacuum. Also radiation absorbing coatings might be required to prevent radiative heat transfer.

To prevent egress of cooking contaminants into the space environment the cooker would have to operate with an essentially sealed air supply. This may cause problems with moisture build up in the air which would have to be overcome, possibly by cooling and condensing out the moisture. Any air released to the environment would in any case require removal of water vapour and probably filtration to remove smells and airborne particulates.

Some degree of smell leakage might be optional depending on how pleasant it is! A facility to rapidly cool the cooking volume and extinguish any potential cause of fire would certainly be required. Rapid thermal quenching could be achieved by cooling with cold fluid and a fire retarding gas could be introduced to starve any fire of oxygen. After any such eventuality the unit would remain sealed until safely jettisoned or returned to Earth for analysis. Water would not be a suitable coolant as it has a low boiling point and could vapourize explosively in a confined space.

All these safety measures including removing any heat source would be triggered automatically be monitoring oven temperature and gas content. Mechanical and manual backup systems would be provided and naturally these systems would have to integrate with any existing ones by providing sensory data for them.

5. Zero Gravity cake oven

This section outlines the solutions adopted for the cooking of a cake (specifically a sponge layer cake) in a zero gravity environment. We choose to cook a sponge cake not because it is easy, but because it is hard. The cake mix exhibits most of the problems described above. It requires the cake mix to be contained in a specific shape as it cooks, it needs to rise evenly and it needs even heating to cook properly.

To solve all of the above problems we propose a rotating oven heated by an electric element with fan assisted air circulation. A variety of foods could be cooked in such an oven by replacing the central rotating container with suitably modified components.

5.1 Artificial gravity

Several solutions in section 4 required an "artificial gravity" to compensate for the zero-g environment encountered in an orbiting spacecraft. This can be achieved by a continuous acceleration in one direction of approximately $10ms^{-2}$ (1g) which exerts a force equivalent to that felt at the Earth's surface on the body being accelerated. However a linear acceleration of even 0.1g for 30 minutes would require the body to travel over a 100 kilometres with a final velocity of over 600 kilometres and hour! Clearly a linear acceleration would not be suitable for producing an artificial gravity for a cake cooker.

It is possible however to achieve a continuous acceleration with a rotational motion. When a body is rotated about a point it experiences a centripetal acceleration with magnitude v^2/r where v is the rotational velocity and r is the radius of rotation. From the rotating frame of the body this appears as the well known centrifugal force which acts outwards on the body. The film 2001 featured a space station design utilising centrifugal force caused by the rotation of the large wheel shaped structure to give an artificial gravity for the inhabitants living on the inside surface of the wheel's rim. How fast would an oven have to rotate to give the desired 1g acceleration? This depends only on how large the radius of rotation is. The following calculations assume a maximum dimension of 50cm for the oven, this means that the radius of rotation could be at most 25cm.

Given acceleration = v^2/r

The rotational velocity is simply the distance travelled per revolution divided the time taken to revolve once. This is just 2*p*r*f where f is the frequency of revolution. Hence

> acceleration = $(4*p^{2}*r^{2}*f^{2})/r = 4*r*p^{2}*f^{2}$
>
> This formula shows that the centripetal acceleration and hence the centrifugal force experienced is proportional to the radius of rotation and increases with the square of the rotational frequency. With SI units and p2 and g both approximately of magnitude 10 we get:

acceleration/g = $4*r*f^2$

Thus if r is 25 cm then f is simply 1 ie. 1 Hertz which in everyday terms is 60 rpm.

Because the acceleration is linearly related to r then over 10% of r it will vary by only 10%. Since we do not know exactly how much force is required for adequate shaping and distribution of the cooking substance the rotation speed should be variable, however a speed of 60 rpm is quite easily achievable (cf. a washing machine that revolves at around 1000rpm)

5.2 Cake dimensions

A rotating radius of 25cm gives a cooker that must be at least 50cm high and wide, this is rather a large size and probably excessively so! Scaling the dimensions down to 15cm still gives a manageable rotational frequency of 1.3Hz (77rpm) for a 1g acceleration.

The cake cooker is based on a rotating cylinder radius 15cm (see Fig. 1). Since the perimeter of a circle is 2*p*radius, it will result in a long strip of cake over six times the radius long. A little thought will point to a potential problem - the outside radius will be 15cm but the inside radius will be less, how much so depending on the thickness of the cake. If the cake were 2.5cm deep then the inside surface will be one sixth as long as the outside surface and hence when removed from the cylinder it will have to deform to compensate for this otherwise the cake will break up (see Fig. 2). With a larger cylinder this would be less of a problem however with a two layer cake it should not matter too much as any broken surface can be hidden between the layers. With a light spongy cake there should be sufficient give to allow a flat cake to be produced with a reasonably sized oven, if not astronauts will just have to get used to eating curved cake or Swiss rolls!

The cylinder is 25cm deep to give roughly square pieces of cake with a 15cm radius when divided into four pieces. A calculation shows that to fill the cylinder to a "depth" of 2.5cm the volume of cake mix required would be almost 6 litres (not allowing for any rising). Since this is rather a large quantity the cylinder is separated into four segments, two of which remain unused (see Fig. 3). Hence only two layers of cake are produced and allowing for a 50% increase in volume due to rising a much more manageable 2 litres of cake mix would be required.

If the cylinder was filled with fluid then it would have a total volume of 17 litres however it is unlikely that it could be usefully utilised completely full. When used with a liquid an internal system of vanes could be added to ensure that all the liquid is pushed to the outside edge of the cylinder and brought into contact with the rest of the liquid ensuring thermal equilibrium.

5.3 Cake heating

To achieve even cooking of the cake heat will have to be distributed to both surfaces of the cake mix as it would in a normal oven. This rules out heating only the outside of the cooking cylinder as would be achieved by wrapping a heating element around it (see Fig. 4). This kind of heating would be suitable for a liquid where normal convection will occur causing heat to be carried to the inside of the cylinder.

With the cake cooker most of the internal volume of the cooking cylinder is empty and hence hot air can be circulated by a fan through the inside and around the outside to give even heating, this will replicate closely the environment of a conventional oven. Heating is achieved using a thermostatically controlled electrical heating element on one side of the cooker's outer container (see Fig. 5). Since the cylinder rotates the asymmetry of the heating within the oven will not be a problem. Air is circulated around the oven by a fan situated at one end of the cylinder through the open end of the cylinder.

Assuming extremely good insulation the oven should require only a small amount of energy to stay at its operating temperature. It is difficult to estimate the amount of energy required to reach the operating temperature since it depends very much on the heat capacity of all the things inside the oven including the walls, heating element, fan and cooking cylinder. Based on a 40cm by 40cm by 30cm volume of air alone it would be about 10kJ which could be delivered by a 500W heating element in just 20 seconds. However the true value will obviously be much higher and if it is a problem then materials of a lower heat capacity will be required. Also once the cake mix is placed inside the oven it absorbs heat while warming up to the ambient temperature and hence more energy is required. A rough approximation with 2 litres of cake mix having properties of water gives a figure of 1400kJ of energy for a 180K rise in temperature. Since this would take a 500W heater nearly 50 minutes to deliver and a typical sponge cake recipe calls for 25 minutes cooking time it is clear that either: the heat capacity estimate is to high, ora much smaller quantity of cake mix will have to be used, ora longer cooking time is required, or more heating power will be required, or the cake mix doesn't completely heat up under normal conditions.

Which one of these is the case will have to be determined experimentally!

5.4 Cylinder mounting and rotation

The cylinder needs to be mounted securely inside the oven and rotated at anything up to 80rpm without any mechanical problems. Also the cylinder must be easily removable from the oven and potentially be sealed if it is to be used for liquids. Three means of mounting the cylinder are illustrated in figure 6. The first involves a central shaft running through the cylinder; however this does not allow the cylinder to be sealed. The second has a central mounting point at each end of the cylinder which is fitted into a retainer. The third has the cylinder mounted in between three rollers fixed inside the oven.

Discarding the first solution the others have the advantage that they both be rotated easily by either an internal or external drive. This would be a small, everyday high speed electric motor with a small diameter driving wheel pushed against the outside of the cooking cylinder. This leaves the ends of the cylinder entirely free of obstruction for either a fan or a transparent viewing port (see Fig. 7). The motor could easily be mounted outside of the heated container with a drive shaft supplied through the container walls. As the shaft would rotate much faster than the cooking cylinder it could also be used to drive the fan. A viscous coupling could be used to reduce heat loss through the drive shaft and to improve isolation.

For simplicity of construction and ease of access the second mounting method has been chosen. Initially the driving motor will also be mounted internally unless the high temperature has a deleterious effect on its operation. The complete prototype design is illustrated in figure 8. Finally, for an operational system, in order to prevent the possibility of causing a rotation of the entire vehicle that the cooker is mounted in, we would probably require a suitable counter-rotating mass, ideally in the form of a second oven rotating in the opposite direction.

5.5 Safety

The design illustrated in figure 8 has no safety features other than that provided by a cutoff switch and a thermostatic control. A practical cooker would have to address all the safety issues previously discussed in section 3.8. The prototype design would definitely need extra internal sensors to monitor the air inside for smoke and pollutants. To prevent the escape of moisture, smoke, smells and other airborne contaminants an air filter would also be required. Safety would also be significantly improved by an external motor, fan and heating element.

6. Conclusions

This paper shows that there are obviously many problems involved in zero gravity cooking but the some if not all of them can be overcome. It is hoped that the design presented in section 5 would solve many of them for one particular case, the cooking of a sponge cake. With interchangeable cooking cylinders it could also be used in the cooking of any other kinds of foods. It does not address the tricky area of food preparation and assumes pre- prepared cake mix is available. However with a higher rotation speed it could even be used as a zero-g food blender!

We hope that some of the ideas presented will be of use in the future of space cookery and again that in some small way may improve the quality of life for future astronauts by allowing them to enjoy some good old fashioned home cooking!

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