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EP 2090419 A1 **WO 2004/041649 A1**
US 6766834 A **US 20090107578 A1**

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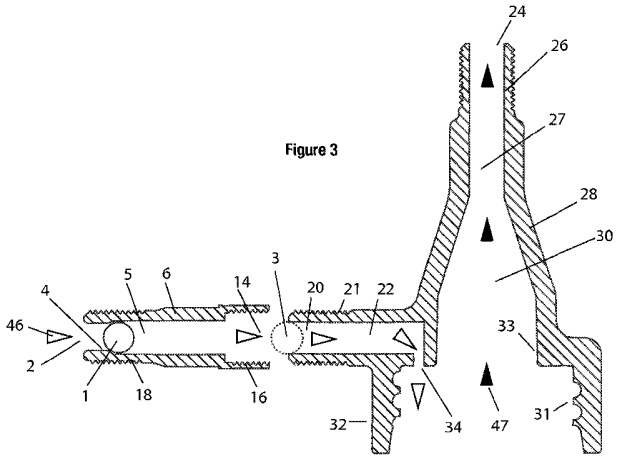
(54) Title of the Invention: **Device for dispensing liquids**
Abstract Title: **Device for dispensing liquids**

(57) A device for the transfer or dispensing of liquids into vessels, such as inflatable articles such as tyres. Such liquids, are typically sealants, balancers, lubricants, coolants and anti-oxidants. The device dispenses liquid from an attached pressure vessel and utilizes a mass-produced, blow-moulded, polyethylene terephthalate (PET) carbonated beverage bottle as a pressure vessel. The device may comprise a body 28 which may be injection moulded plastics with a gas inlet 20 and liquid outlet 24. The body may include a coupling 32 allowing it to be attached to a PET bottle containing a liquid such as a tyre sealant. The inlet may include a metal valve assembly 6 (7, figure 4) which may comprise a pressure release device in the form of a silicone rubber sleeve (8) which can distort to release pressure to prevent over-pressurisation of the PET bottle in use. A uni-directional valve comprising a ball 1 may inhibit back flow of liquid. The liquid flow path 30, 27 is smooth straight and clear to promote laminar flow making the device suitable for use with liquids containing fibres, ultra-micro fibres and nano-fibres which are prone to clogging internal galleries.

Figure 3



GB 2482016 A

Figure 1

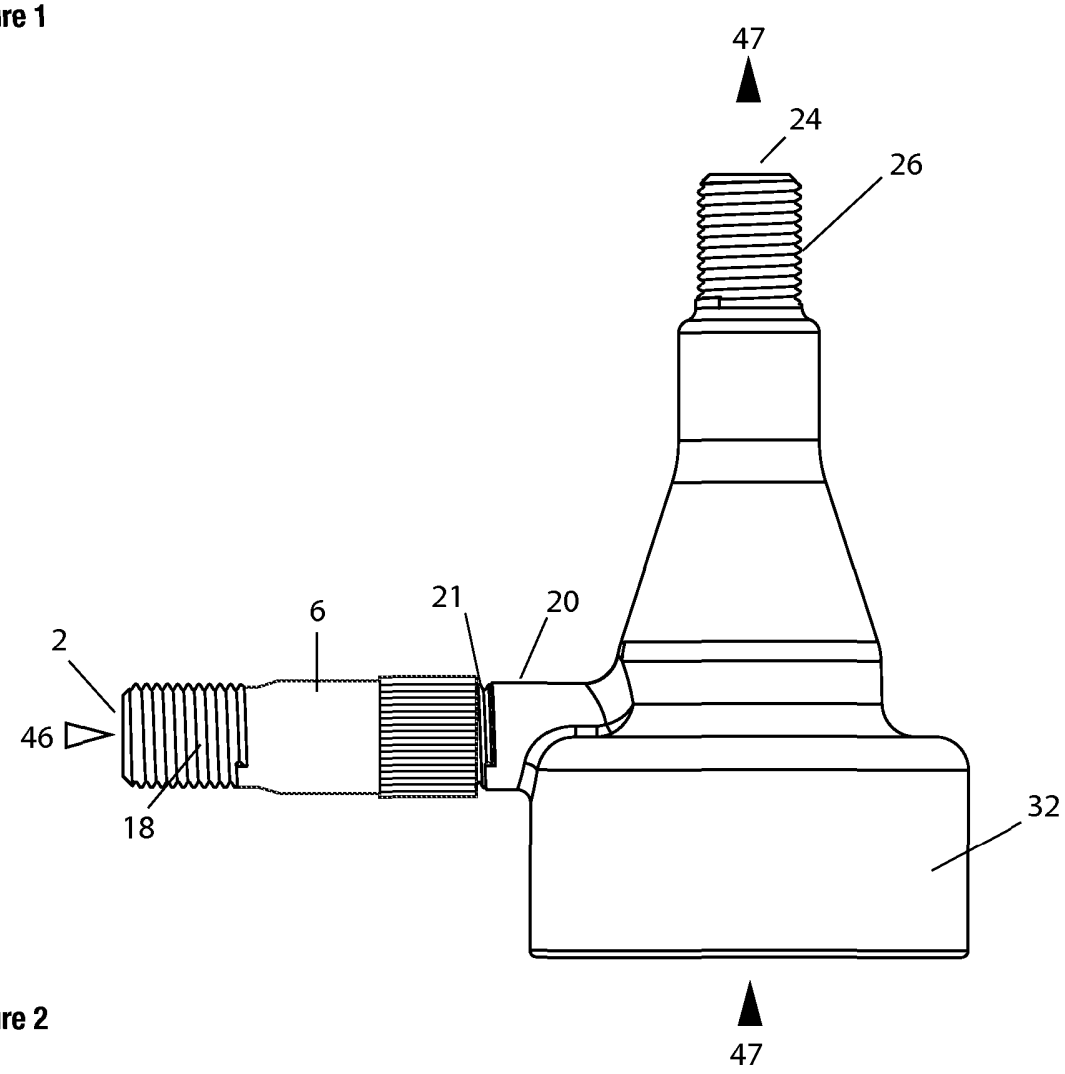


Figure 2

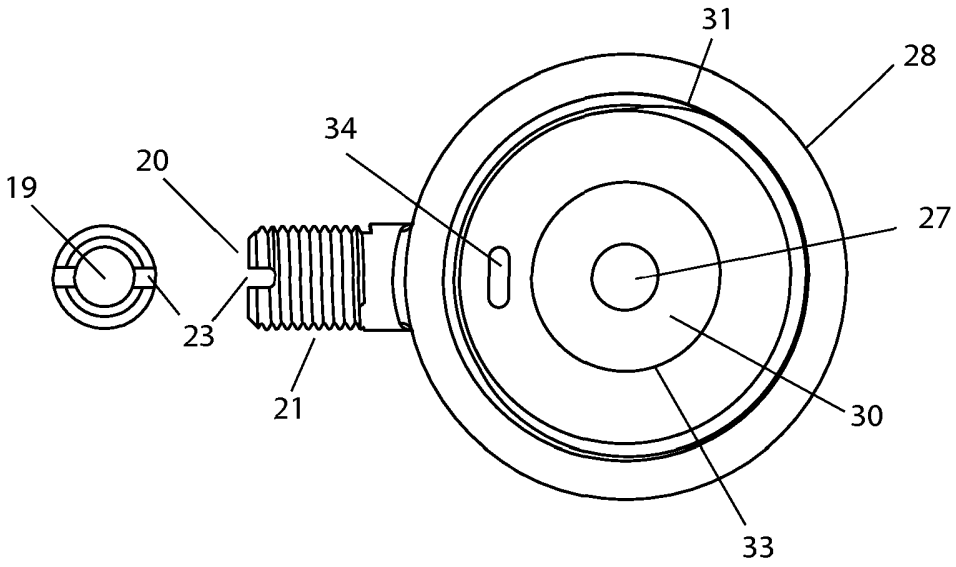


Figure 3

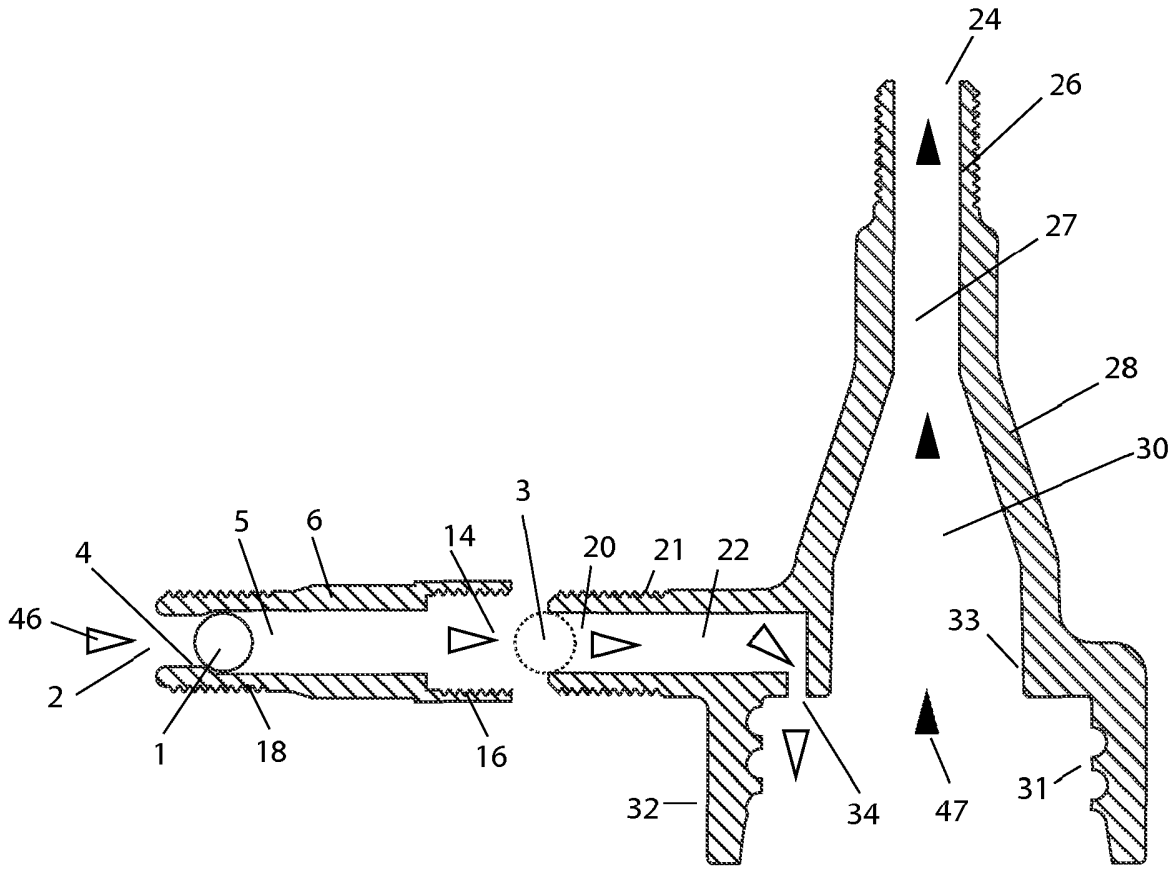


Figure 4

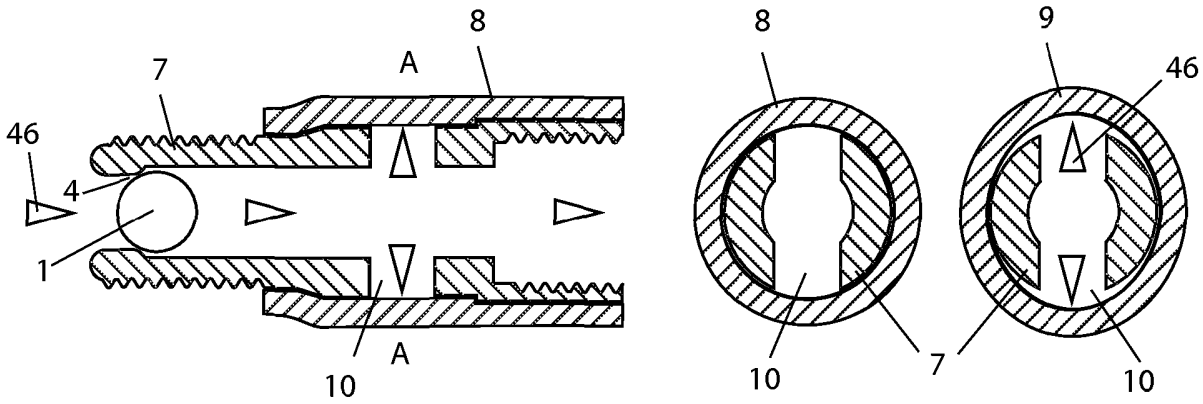


Figure 5

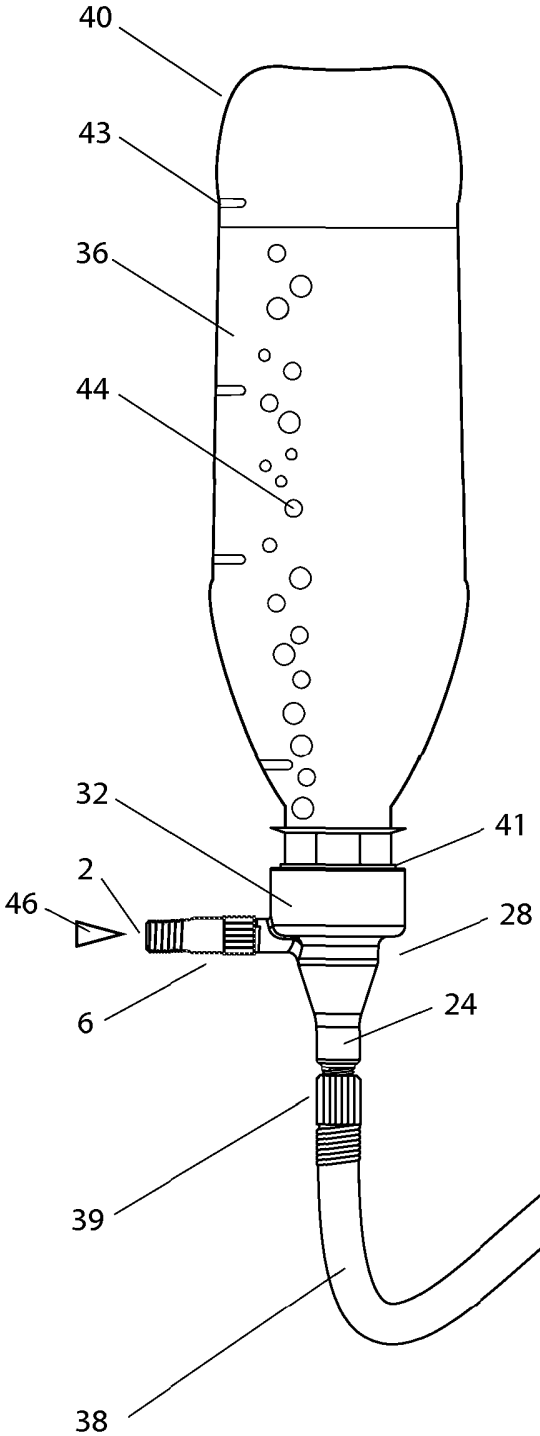
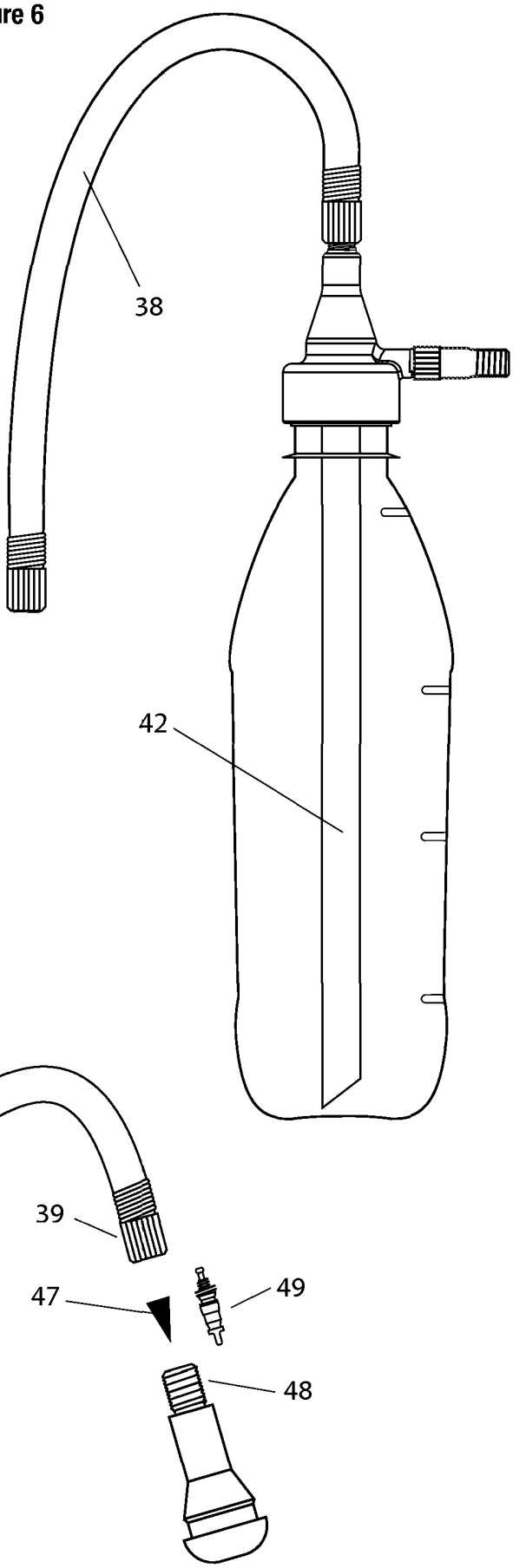


Figure 6



Device for dispensing liquids

Background to the invention

One important application of the present invention is introducing liquids into tyres. Such liquids, for use with tyres, are typically sealants, balancers, lubricants, coolants and anti-oxidants. In the case of sealants, the reason for introducing a liquid is to confer self-sealing properties to the tyre either as a preventive measure to seal punctures automatically as they occur or as an emergency repair of a punctured tyre.

Commonly used methods of introducing sealant into a tyre utilize the package in which the sealant is supplied. One package type is a flexible plastic bottle supplied with a spout or tube. To inject the sealant into a tyre, the user pushes the spout into the tyre valve stem or fits the tube over the valve stem. The user then squeezes the bottle manually to displace the contained sealant into the tyre. This method does not encompass a means of inflating the tyre and thus requires additional equipment.

Another package type used for introducing sealant into a tyre is an aerosol can where the nozzle is fitted with a tube terminated with a connector that screws on to the valve stem. When the nozzle is depressed a propellant (compressed gas or liquified gas) within the can drives the contained sealant (typically latex-type) into the tyre via the tube. The propellant is also used to inflate or partially inflate the tyre.

An emerging system for introducing sealant into tyres is a device integrating a portable compressor and a cartridge charged with sealant (again typically latex-type). Various mechanisms utilize compressed air from the compressor to drive sealant from the cartridge into the tyre via a tube terminated with a connector that screws on to the valve stem. The compressed air is also utilized to inflate the tyre after addition of the sealant. Increasingly, systems of this sort replace the spare wheel conventionally carried by a vehicle, thus saving weight and space with a consequent benefit in terms of the vehicle's energy efficiency. In such systems, examples of which are tyre repair kits marketed by companies such as Continental Tyre, Dunloptech, Terra-S and Slime, the cartridge containing sealant is a proprietary moulded pressure vessel.

A patent by Takumi Sekiguchi (Yokahama Rubber, TYRE SEALANT LIQUID CONTAINER, US 20100071822) refers to integrated compressors and sealant containers or sealant containers intended to be used with a compressor.

A further method of introducing sealant into tyres utilizes dedicated equipment connected to an external source of compressed air or gas. Such equipment is not currently in common use.
The currently used methods of introducing sealant into a tyre, as outlined above, have several disadvantages.

The first method described – utilizing bottles with spouts and tube fitments – is inconvenient and time-consuming. The process of injecting tyres with sealant from such packages involves significant manual effort because the orifice of a tyre valve is typically just 3mm diameter and the liquid being dispensed is invariably viscous or contains particulate or fibrous matter. Furthermore, typically, such bottles are relatively inflexible, making manual compression difficult. The bottles referred to above are disposable. Thus the means of connection to the tyre valve stem is desirably low in cost. This typically precludes the use of an effective connection to the valve stem, which would generally be unacceptably expensive as a disposable item. The consequent lack of an effective connection to the valve stem can lead to failures in the injection process, e.g. the tube might be displaced due to excessive manual pressure allowing leakage of sealant, resulting in a messy operation.

The second method described – utilizing aerosol packaging – has a number of disadvantages. Aerosol sealants are limited to those formulations that will flow through the nozzles and valves used by aerosols. This precludes the use of sealants using viscous liquids, particulate matter or fibres, the latter being a particularly effective means of sealing punctures.

Therefore, generally, the use of an aerosol implies the use of latex-type sealant formulations which also have a number of disadvantages. Latex (which relies on a solidifying action on contact with air to effect seals) can dry out in the tyre.

This makes its removal from the tyre difficult when a permanent vulcanised repair is made as is required for motor vehicles in many legislations. It is not unusual for tyre fitters to refuse to repair tyres containing latex sealant and thus an expensive tyre replacement becomes necessary, even where the extent or location of puncture damage would not normally require such replacement. Latex does not have the sealing capability achievable, for instance, with fibres, such as those employed in the self-seal tyre gel as manufactured and marketed by the applicant. As explained above liquid latex, when exposed to air, reverts to solid rubber so that this type of sealant can only be used for emergency puncture repair. In consequence, latex-type formulations cannot be used as a means of conferring self-sealing properties to tyres as a preventive measure such that punctures are sealed automatically as they occur.

Further disadvantages of the aerosol as a means of injecting tyres with sealant are as follows. Firstly, it is not unusual for the volume of propellant in a typical aerosol to be insufficient to fully inflate a tyre, especially today's wide section and SUV tyres. Thus, after repair by aerosol, tyres are often driven under-inflated – with attendant risk of tyre failure. Secondly, aerosols often employ inflammable propellants that have, in the past, been responsible for the deaths of tyre fitters who were smoking while working on tyres repaired using such products. Thirdly, propellants can also be harmful to the ozone layer. Finally, the cans used for aerosols are difficult to recycle and can be a hazard when heated above a certain temperature.
The third method described – the use of a device integrating a portable compressor with a cartridge or container of sealant– also has a number of disadvantages. This type of device is referred to as a tyre repair kit in the following text.

Typically the sealant cartridges for tyre repair kits are relatively expensive because they are proprietary, are custom moulded as a pressure vessel and typically contain or require complex mechanisms to enable the ejection of sealant and injection into tyres. The cost factor is magnified when consumers need to buy cartridge refills after having utilized the kit to repair a puncture.

Further, because tyre repair kits integrate a proprietary compressor and cartridge, consumers cannot generally buy cartridge refills and use them with a tyre inflation system they already own or one with special features they wish to use. This further increases cost and reduces choice for the consumer.

Tyre repair kits are often intended as a spare wheel replacement for motor vehicles where weight reduction is increasingly an important factor in increasing fuel efficiency and reducing CO2 emissions. Further, modern wheels with wide-section tyres are sufficiently heavy to make the task of changing a wheel at the roadside impossible, as well as dangerous, for most car drivers, particularly women. Space saving is another benefit of eliminating the spare wheel. The present invention maximises this benefit by providing a device that is significantly more compact than current tyre repair kits and thus provides a system sufficiently small to be carried by motorcycles for emergency tyre repairs.

Most tyre repair kits utilize latex-type sealants which have the disadvantages outlined above and, particularly, they lack the flexibility to be used as a preventive self-seal system where this is appropriate. As with aerosols, the latex sealant emerges from its container as a foam that will pass through a tyre valve without the need to remove the valve core.

A disadvantage of particulate or fibre-based sealants is that they require the valve core to be removed (while the sealant is injected) so the sealant can flow through the valve. The present invention seeks to mitigate this disadvantage.

It is mentioned above that tyre repair kits and dedicated devices employ a number of different mechanisms by which compressed air from an integrated compressor or compressed gas from an external source is used to eject sealant from a cartridge or similar vessel and inject it into the tyre. There is a surprising variety of such mechanisms described in the literature. Many are relatively complex and all are bulky in comparison with the present invention. These mechanisms can be summarised as follows.

A mechanically-operated plunger (syringe-like) which displaces sealant from a cartridge fitted with said plunger as described in US 4308766.

EP 0 832 763 A2 describes a mechanism, utilizing what is often referred to as a 'two-pack' system. This generates a sealant from two or more components and then injects the tyre with the resulting product.

A mechanism using compressed air to move a plunger within a container of sealant such that gas and sealant do not come into contact as the sealant is injected into a connected tyre. Such a mechanism is described in EP 1 728 619A2, US 7,021,348 B2, EP 189 47 07 A1 and EP 123 892 3 A2

US 5251787 describes a mechanism which utilizes compressed air to collapse a semi-flexible bottle or bladder within a pressure vessel forming part of the apparatus such that sealant within the bottle or bladder is displaced into a connected tyre.

A mechanism which utilizes compressed air to inflate a bladder within a container of sealant such that the sealant is displaced into a connected tyre is described in: US 7,389,800 US 2008/0202632 A1.

A mechanism which utilizes compressed air together with the venturi effect to create a negative pressure at the opening of a sealant container such that sealant is extracted and propelled into a connected tyre. For example as described in: EP 1419876 B1 and EP 1621324 A1

A mechanism which utilizes compressed air within a dedicated pressure chamber vessel to induce a cyclonic current of gas which causes contained sealant to be withdrawn from the container and injected into a connected tyre (US 5472023).

Use of compressed air introduced directly into one end of a dedicated tubular container to displace sealant from the opposite end of the container into a connected tyre (US 5,908,145).

Use of compressed air introduced directly into the opening of a bottle or a vessel containing sealant such that the liquid is expelled into a connected tyre via an outlet when the bottle, with apparatus, is inverted. Gas is either bubbled through the liquid from the bottle opening or introduced via a tube extending from the bottle opening to the air / gas space above the liquid. Examples are as described in: US 2004/0173282, US 6283172 and EP 2090419 A1.

A mechanism as described in the previous paragraph above, but utilizing a pick-up or riser tube within the bottle or container such that liquid is expelled under pressure, via the tube, without need to invert the bottle (WO2007030896A1, US6176285, EP1815970B1).

A mechanism as described in the previous two paragraphs above but integrated with a portable compressor. Typically the compressor is mounted within an enclosure providing a convenient means of attaching a bottle filled with sealant. Such bottles are invariably custom-designed pressure vessels that screw on to the apparatus. A mechanism is sometimes provided so that the bottle can be fitted while remaining sealed. Once fitted, the mechanism opens the bottle, for instance, by piercing a sealing membrane across the opening of the bottle. For example as described in: US 2010/0005930, US 0613320, US7694698, US D597574, US 0611076

As will be evident from the above, a number of mechanisms employ the principle of using compressed air or gas directly to eject sealant from a cartridge or pressure vessel. With such mechanisms there is a risk of the sealant flowing back to the source of compressed air or gas once the inlet pressure is less than the pressure in the vessel containing the sealant. This happens, for instance, when the source of air or gas is turned off. Particularly in the case of sealants that function through a change of state on contact with air – such as latex-type formulations – there is a risk that flow-back may result in a blockage of the supply hose or damage the source of compressed air or gas.

An example of a solution to this problem is illustrated by Japanese patent application Kokai publication number 2008-23909 which discloses a sealing and inflation device having a housing in which a compressed air supply channel and a gas/ liquid supply pipe line are connected to a sealant container. In this proposal, the compressed air supply channel and the gas/ liquid supply pipeline wind their way in the housing so as to be partially positioned above the liquid level of a sealant in the sealant container. Such a structure in which pipelines wind their way in a housing can prevent flow-back or leakage of a sealant. However, the structure requires the housing to accommodate the pipelines, and thus increases the size, complexity and cost of the whole device.

Some other devices using mechanisms as described above, employ various designs of uni-directional valve to prevent flow-back of sealant.

Description of the invention

The present invention was created with a number of objectives: Firstly and, in particular, to enable the injection of liquids into tyres for the purpose of conferring self-sealing or self-balancing characteristics on tyres or, alternatively, to repair an already-punctured flat tyre.

Secondly to simplify the equipment or device required to achieve the above objective such that it is low in cost and easy to use for consumers, as well as being compact and light in weight to suit modern energy-efficient vehicles.

Thirdly to enable the reliable use of a high-performance ultra-micro fibre-based self-seal tyre gel such as that manufactured by the applicant, as well as future nano fibre-based products. It should be noted that said fibres are a very effective means of sealing punctures but state-of-the-art devices are unreliable or unusable when used with products of this type because clogging or blockage of internal galleries within these devices is likely.

These objectives are achieved by the present invention through its use of a mass-market PET (polyethylene terephthalate) bottle – as both retail pack and pressure vessel. The attributes of the present invention imply that the device can become universally available to consumers such that it is affordable for use, in particular, with all the tyres a household owns (as fitted to car, caravan, trailer, mower, wheelbarrow, bicycle, total mobility vehicle etc)

The present invention, known as a PET-pump, is able to use a PET bottle (which is normally intended for carbonated beverages) as a pressure vessel because of the bottle's surprising capability to withstand very high pressures. For instance, it has been reported that the burst point of PET bottles can be as high as 13 bar. 10 bar is accepted as the normal maximum pressure PET bottles must withstand. This high-pressure capability has become necessary because carbonated beverages can generate very high internal pressures when warmed. These bottles, available in a range of sizes from 330ml to 2 litres, are an ideal and widely available package for the marketing of products such the self-seal tyre gel manufactured and marketed by the applicant.

In a preferred embodiment of the present invention, a simple and low-cost pressure-relief mechanism is incorporated in the PET-pump so as to limit the pressure that is applied to an attached PET bottle. In this way, operating pressure of the bottle is prevented from exceeding the maximum safe limit.

The PET-pump screws on to a PET bottle in place of its closure. When used to inject liquid into tyres, the PET-pump attaches to the tyre valve stem by means of a short hose. The PET-pump provides a gas inlet with a standard Schrader tyre valve thread. This universal connection allows the attachment of a range of inflating devices as the source of compressed air or gas required for operation of the PET-pump. Examples of inflating devices include portable compressors, hand and foot pumps, CO2 cartridges etc.

Application of pressure to the gas inlet causes air or gas to pass into the PET bottle thus displacing the contained liquid when the bottle is inverted – a convenient orientation for injecting tyres. Transfer of liquid from bottle to tyre, using the PET-pump, takes 15 to 20 seconds for 500ml (a typical quantity for a small car tyre) – with no manual effort required by the user.
To prevent possible clogging of inflating devices while the device is in use, the PET-pump incorporates a uni-directional valve which prevents back flow of sealant into the inflating device. Using what would appear to be a novel design, the uni-directional and pressure-relief valve functions are combined in a very simple, low-cost unit that provides a durable metal thread to allow for multiple connections to inflating devices over time. The device is also easily detachable from the PET-pump for the purpose of cleaning should that ever be necessary. This functionality should be contrasted with the state-of-the-art where uni-directional valves are not easily accessible to the user, would be subject to clogging with a product containing ultra-micro fibres or nano fibres, and generally are not simple in construction. Further benefits of the present invention in this respect are discussed below.

The patent would appear to accept the general prior art of displacing a liquid from a container using compressed air or gas. The patent refers to what is regarded as a unique device to utilize a PET bottle as both the pressure vessel required for its operation and as the package used for the marketing of said liquid. The valve functionality referred to above is integral to the device's utilisation of a PET bottle as a pressure vessel.

As discussed above, cost reduction compared to the state-of-art, as a system, is achieved through the use of PET bottles in contrast to relatively expensive special-purpose cartridges. The low cost achievable for a retail package is of particular benefit when a consumer wishes to utilize the PET-pump to protect multiple tyres because refills of self-seal tyre gel can be inexpensive and easy to obtain. Cost reduction is also achieved through the design of the PET-pump itself – which is a simple injection-moulding little larger than a normal PET bottle closure. A flexible system is achieved by the PET-pump because it does not have to be bought with or used with a dedicated inflation system. This is of particular benefit if consumers already own a tyre inflation device – as many do.

A specific function of the PET-pump is to allow optimal injection of the applicant's self seal tyre gel product, called 'PSi', into tyres. PSi is unusual and probably unique in its use of ultra-micro fibres whose length is orders of magnitude greater than their diameter. By way of illustration of this characteristic, 1-litre of PSi gel contains 100 kilometres of fibre, chopped into 17 million threads. This characteristic is at the root of the powerful and reliable sealing action that is achieved by PSi without the negative side-effects often associated with puncture sealants. However, this same characteristic makes PSi likely to seal the internal passages and galleries of pumping equipment unless there is a short, smooth straight and clear path through which the fibres can pass as a laminar flow. The tendency of the fibres to combine into a rope-like plug when confronted with a flow path other than that described above preclude the use of typical domestic-type dispensing systems such as aerosols and so-called 'Pelican pumps'. It also precludes the use of state-of-the-art devices which invariable do not provide a short clear path through which the sealant passes during the tyre injection process.

Introduction to drawings

The invention will now be described solely by way of example and with reference to the accompanying drawing in which:

Figure 1 illustrates a side view of the PET-pump. This illustration, in conjunction with figures 5 and 6, demonstrates the ultra-compact dimensions of the device. Figure 1 shows the gas inlet (2) and the liquid outlet (24). In this embodiment, both inlet and outlet, as illustrated, provide standard Schrader-type threads as used for tyre valves (although alternative interfaces can be employed as appropriate). The arrow (46) shows the direction of flow of gas provided by an external device such as a compressor.
The arrows (47) show the direction of liquid flow. Liquid originates from a PET bottle attached by the coupling (32) using the thread (31).

Figure 2 illustrates a bottom view of the PET pump showing the internals of the PET-pump body (28): the outlet gallery (27), the internal chamber (30), the thread (31) of the coupling (32), the socket for an optional pick-up tube (33), and the gas inlet jet (34). It should be noted that the jet is of a smaller internal area to the outlet gallery (27). To one side, the PET-pump gas inlet (20) is shown. It is provided with a thread (21) for the attachment of the valve (6) which is not shown in this figure. The inlet is provided with a slot (23), illustrated in side view and end view. This slot allows gas flow past the ball (3) (not shown in this figure but shown in figure 3), when the ball moves to the inlet (20) under inlet gas pressure.

Figure 3 is a mid-line cross section through the body of the PET-pump (28) and the valve (6). The direction of gas flow is indicated by the arrows (46) as gas passes from a device such as a compressor, into the valve inlet (2), through the gallery of the valve (5), into the PET-pump inlet (20), along the inlet gallery (22) and then exits via the jet (34) into an attached PET bottle. A PET bottle is attached to the PET-pump by the coupling (32). Liquid displaced by the pressurised gas in the bottle enters the PET-pump chamber (30) and thence into the outlet gallery (27) to exit via the PET-pump outlet (24). The direction of flow of the liquid, when the apparatus is inverted, is indicated by the arrows (47). The passage through the centre of the PET-pump is designed to present a path that encourages a laminar flow of liquid through the device.
Liquids that, for instance, contain ultra-micro or nano fibres require a flow path that is not convoluted, is free from protrusions into the path of the liquid, where changes in diameter of the flow passage are progressive and where the length of the passage is minimised. These design features are essential if fibres intended to plug, for instance, the damage penetration channels of tyre punctures do not also block the internal passages of pumping equipment.

It will be seen from figure 3 that these features are achieved and testing confirms that there is no build-up of fibres within the PET-pump when used to dispense large volumes of liquid containing ultra-micro fibres. Figure 3 also shows a valve assembly (6 or 7) which connects to the PET-pump by means of the threads (21 and 16), thus allowing the valve to be easily detachable. A further embodiment of this valve assembly is illustrated in figure 4. The valve assembly contains a steel ball (1) which moves to the position indicated (3) when inlet pressure exceeds that in the gallery (22). When gas pressure in the gallery exceeds the inlet pressure, the ball moves such that it forms a seal with the valve seat (4). Standard Schrader-type threads (18 and 26), allow convenient connection to inlet and outlet hoses respectively. Whereas the body of the PET-pump is preferably plastic, the valve body is preferably metal so as to protect the plastic thread (21) by presenting a durable metal thread for the connection of inflation devices. In an embodiment of the present invention where a pick-up tube (42) (not shown in this figure but shown in figure 6), is utilized, said tube is inserted into the socket (33).

Figure 4 illustrates an embodiment of the valve (7), where a gas exhaust or exhausts (10) are provided. The exhausts (10) are sealed by a surrounding, tight-fitting silicone rubber sleeve (8). Gas passes in the direction indicated by the arrows (46). Gas within the valve gallery cannot exit via the exhust/s until the internal pressure rises to a pre-determined level whereby distortion of the silicone rubber sleeve occurs such that gas is allowed to escape, thus reducing the pressure inside the apparatus. The embodiment described also incorporates a non-return valve mechanism using the ball (1) which mechanism is described as for figure 3. Also illustrated are cross-sections of the valve assembly at the position designated by 'AA'. These sections show the sleeve in its normal state (8) and when distorted (9) by internal gas pressure exceeding a pre-determined level. When such distortion of the sleeve occurs, as shown, gas can escape through the exhaust/s (10) in the direction indicated by the arrows.

Figure 5 illustrates an embodiment of the PET-pump without a pick-up tube. This embodiment requires the apparatus to be inverted in use as shown. A source of pressurised gas is connected to the inlet valve (6) to provide a gas flow as indicated by the arrow (46). Gas passes into the PET bottle via an internal jet (34) within the PET-pump (see figure 2) and then bubbles up through the liquid in the bottle. Pressure builds up in the bottle so displacing the contained liquid through the outlet (24). This outlet (24) is connected to an inflatable device (such as a tyre) via a hose (38) with threaded couplings (39).

In the case of the PET-pump being connected to a tyre, the valve core (49) is first removed from the valve stem (48). The arrow (47) indicates the direction of liquid flow under gas pressure.

Figure 6 shows an embodiment of the PET-pump utilizing a pick-up tube (42). The pick-up tube is dimensioned in length so as to extend to within approximately 3mm of the bottom of the PET bottle and in diameter so as to be a press-fit in the socket (33) as illustrated in figure 3. Fitment of the pick-up tube allows the apparatus to be used without inversion. Internal gas pressure within the bottle causes the contained liquid to pass up the pick-up tube into the PET-pump and exit via the hose 38. Otherwise the apparatus, fitted with the pick-up tube, functions as described for figure 5.

Detailed description

The present invention relates to a device for the rapid and convenient transfer or dispensing of liquids into vessels, an example being inflatable articles such as tyres. Such liquids, for use with tyres, are typically sealants, balancers, lubricants, coolants and anti-oxidants. The device is a simple direct-acting gas-operated pump that dispenses liquid from an attached pressure vessel.

The device covered by the present invention, referred to as a PET-pump, utilizes disposable plastic bottles that are capable of being pressurised. Typical of such bottles are those manufactured from polyethylene terephthalate (PET – hence PET bottles) which are designed to contain carbonated beverages where internal pressures can reach as much as 10 bar. It has been reported that the point at which PET bottles burst can be as high 13 bar. With the present invention, said bottles, ranging in capacity between 330ml and 2,000ml, are used as both the package in which liquids to be dispensed are marketed and the pressure vessel required for the PET-pump to function.

The PET-pump consists of the following components (figures 1 to 6 refer):

i) A body (28), preferably injection-moulded plastic, with a gas inlet (20) and outlet (24) for liquid and a coupling (32) to the PET bottle;

ii) A metal valve assembly (6) or (7) with an inlet (2) and an outlet (14);

iii) Optionally, the PET-pump is fitted with a pick-up tube (42).

The PET-pump screws on to the PET bottle neck which becomes a direct inlet for liquid passing into the pump. To achieve reliable operation, the PET-pump utilizes a short straight path between outlet (24) and PET bottle. In practice, a path just 5 cms long is achieved. This path reduces progressively and smoothly from the relatively large internal diameter of the bottle neck to relatively small internal diameter of the outlet (24) which is a similar dimension to the internal bore of a tyre valve. Typically the PET-pump attaches to the vessel into which liquid is being dispensed by means of a hose (38). The configuration described results in laminar flow of liquid from bottle to final destination. The benefit of and need for this particular aspect of the design is explained below.

The PET-pump provides an inlet (2) for pressurised gas which is used as the means of displacing liquid from the PET bottle. The embodiment illustrated utilizes a standard Schrader-type thread (18) on the inlet to facilitate the connection of an air inflation device, compressor, CO2 cartridge, bicycle pump etc.

In a preferred embodiment (also illustrated) this inlet is fitted with a metal valve assembly (6) that is also provided with Schrader-type threads. In this way, assuming the use of a plastic injection-moulded PET-pump body, the plastic thread of the inlet is converted to durable metal one suitable for multiple connections, over time, to inflation devices – such that the thread does not become worn or damaged by constant attachment of connectors which are typically metal. The valve assembly provides uni-directional and pressure-relief valve functions which are described below.

The gas inlet (20) of the PET-pump connects to the internal space of the bottle via a jet (34) drilled or moulded into the internal periphery of the device.
The basic method of operation of the PET-pump by a user can best be described by reference to an application of the present invention. For instance, for the purpose of conferring self-sealing or self-balancing characteristics on a tyre or, alternatively, for the purpose of repairing an already-punctured flat tyre, the PET-pump is used as follows:

i) The closure of the PET bottle (40) containing the liquid to be injected into the tyre is removed. Typically the PET bottle will be the retail pack for the liquid.

ii) The coupling (32) of the PET-pump is screwed on to the neck (41) of the PET bottle (40).

iii) A source of compressed gas is connected to the valve inlet (2).

iv) The valve-core (49) within the valve stem (48) of the tyre to be injected with liquid is removed using the valve core screwdriver typically provided with the PET-pump.

v) The hose connector (39) is attached to the valve stem (48) of the tyre to be injected.

vi) The PET bottle (40) is inverted so that the PET-pump outlet (24) faces down.

vii) The flow of compressed gas is activated by the user for a few seconds. This causes a gas flow (46) through the valve gallery (5) and the PET-pump inlet gallery (22). The gas then passes through the jet (34). With the bottle (40) inverted, gas bubbles (44) rise through the contained liquid (36) and pressurise the space above the liquid in the bottle (40). This pressurisation causes liquid to be expelled through the outlet gallery (27) of the PET-pump and enter the tyre via the hose (38) and the tyre's valve stem.
viii) The volume of liquid injected into the tyre can be determined using the calibrations (43) on the bottle label (40). Gas flow is activated by the user in a few short bursts until the required volume of liquid has been expelled.

ix) The hose (38) is then detached from the tyre's valve stem (48) and the valve core (49) replaced in the valve stem. This process can be achieved without deflating the tyre, as is outlined below.

An alternative embodiment utilizes a pick-up tube (42) extending from a socket (33) internal to the body of the PET-pump to the bottom of the bottle. In this case, the application of pressurised gas to the inlet (2) causes the contents of the bottle to be displaced via the tube without the need to invert the bottle.

The use of a valve core removal tool is mentioned above. The tool provided with the PET-pump is of a type that grips the end of the valve core and holds it while it is removed from the valve stem (48). The valve core can therefore be removed rapidly with one hand while the hose (38) is subsequently and rapidly connected to the tyre valve stem (48) using the other hand. In this way, the hose can be connected to the valve stem with minimal loss of air. Likewise, after injection of the sealant using the PET-pump, the hose can be detached and the valve core re-inserted with minimal loss of air. In this way, sealant can be injected into a tyre without the necessity of full deflation of that tyre.
An important aspect of the present invention is that it should provide reliable operation with the self-seal tyre gel, known as PSi, which is manufactured and marketed by the applicant. PSi utilizes, principally, ultra-micro-fibres whose length is orders of magnitude greater than their (micronic) diameter. The product employs fibres of this sort because they can penetrate a wide range of puncture types and sizes. The fibres combine within the puncture damage penetration channel to form a rope-like, air-tight plug extending beyond the thickness of the tyre rubber. Thus seals are achieved without oxidative processes or the use of glue-like compounds which can lead to negative side-effects. The characteristic of these fibres, used in this way, means that they would clog state-of-the-art devices which typically utilize convoluted internal pathways or galleries to transfer liquids to tyres. Many such devices employ internal valves which are difficult to access by the user should a blockage occur. Thus the PET-pump has been designed as described above.

Although PET bottles are capable of withstanding very high internal pressures, for the safety of the user, various design features are incorporated within the PET-pump. Firstly the internal jet (34) is smaller than the outlet (24) such that gas can escape faster from the bottle than it is introduced. Secondly, the valve assembly (6 or 7) that screws on to the gas inlet (2) provides one or two exhausts for the escape of gas to free air should higher than the required internal pressure build up. These exhausts are sealed by an elastic sleeve (8) (such as silicone rubber). The dimensions of such sleeve (typically a wall thickness of between 1 and 3 mm) can be adjusted so that, at the desired pressure, the sleeve displaces sufficiently from the exhaust/s to allow the escape of gas. A whistle, alerting the user to fact that sufficient inlet of gas has been applied, accompanies such escape of gas. The valve is illustrated in figures 3 and 4 which shows midline sections of the valve with and without the pressure-relief function.

Another function of the valve assembly (6 or 7) is that it incorporates a unidirectional valve that prevents back flow of sealant and gas. While the use of a uni-directional valve is not novel, integration of a non-return function with a pressure relief valve in one easily removable device is believed to be novel. Easy removal is convenient for the user should the valve need cleaning. Further, as a separate component, the valve assembly can utilize different designs to achieve the desired functionality – while the design of the injection-moulded PET-pump remains unchanged.

The uni-directional valve functions as follows. When gas pressure is applied to the gas inlet (2), the ball (1) moves to the inlet of the PET-pump (20). To prevent the ball from occluding the PET-pump inlet, a slot (figure 1, item 23) is provided at the inlet. This creates a passage through which gas can pass when the ball is in this position under inlet gas pressure. This arrangement further limits the rate at which gas can enter the PET pump in relation to the rate at which it can exit.

When gas pressure in the valve gallery (5) exceeds that at the valve inlet (2) the ball (1) forms a seal with the valve seat (4). This action serves three functions. Firstly, the valve gallery (5) remains pressurised such that liquid does not enter and clog the PET-pump jet (34). Secondly it prevents liquid entering the valve gallery (5) such that it does not, subsequently flow into the inflating device or a hose connecting it to the PET-pump. Thirdly, it allows the PET-pump to inject liquid into an inflatable device (such as a tyre) without deflating, or at least partially deflating, that device. In the case of a tyre, this eliminates the time that would be involved in deflating that tyre and then in inflating it.

In summary, the unique features of the PET-pump are that it enables the use of universally available, low-cost PET bottles in a low-cost device, ideal for mass production that has only one moving part (a ball) with a functionality optimised for difficult-to-pump liquids such as those containing ultra-micro fibres or nano fibres. The PET-pump is ultra-compact and light in weight. In automotive applications, these attributes make the PET-pump an ideal spare wheel replacement in vehicles where compactness and overall weight are critical to the achievement of energy efficiency. In this application, the device enables rapid, effortless injection of liquids to confer the functions, for instance, of self-sealing, self-balancing, cooling, lubrication, corrosion inhibition (for rims and internal sensors) etc. The PET-pump is easily cleaned and re-usable. The PET-pump can be used with any portable compressed gas source that is suitable for tyre inflation. The design of the PET-pump is such that it can employ a detachable valve incorporating a pressure-relief valve (to prevent over-pressurisation of the PET bottle and to provide a uni-directional flow function).

As a separate component, the valve is easy to clean and can utilize different designs to achieve the desired functionality while the design of the injection-moulded PET-pump remains unchanged. Also, the valve, by utilizing metal construction, presents a metal thread (18) for the connection of the devices providing pressurised gas – thus protecting the less-durable plastic thread of the PET-pump itself.

Claims

1. Device enabling the use of a mass-produced, blow-moulded, polyethylene terephthalate (PET) carbonated beverage bottle or any other such bottle capable of withstanding high internal pressures as a package for the marketing of liquids in addition to the use of said bottle as a pressure vessel for the purpose of rapid and convenient transfer or dispensing of liquids into vessel.

2. Device according to claim 1 comprising:
- a gas-tight thread or coupling for attachment to the device of a PET bottle or other bottle capable of withstanding high internal pressures where said bottle contains a liquid;
- an inlet for pressurised gas leading to galleries within the device that allow the controlled introduction of said gas into the PET bottle such as to displace said liquid via an outlet closely positioned to the neck of the bottle;
- valves providing protective and convenience functions
- an interface for the attachment of an inflating device or source of compressed gas.

3. Device according to claim 1 and 2 whereby the device is a simple, ultra-compact one-piece design such as to facilitate low-cost mass production using.

4. Device according to claim 2 whereby the flow-back of liquid and gas from said device to the gas inlet is inhibited by a unidirectional valve.

5. Device according to claim 2 whereby over-pressurisation of the PET is prevented by a pressure-relief valve of novel design

6. Device according to one of the previous claims where the uni-directional valve and the pressure-relief valve form one device.

7. Device according to one or more of the previous claims whereby the valve assembly, utilizing one moving part and utilizing industry-standard Schrader threads, is detachable, thus facilitating low-cost mass production.

8. Device according to one or more of the previous claims whereby the valve assembly is easily removable for cleaning or interchange with another assembly of different specification.

9. Device according to one or more previous claims whereby the internal design of the device has a smooth straight and clear path through to permit the laminar flow of difficult-to-pump materials such as those prone to clog the internal galleries of a device, including liquids containing fibres, ultra-micro fibres and nano fibres.

10. Method according to previous claims for injecting tyres using liquids such as self-seal gel, self-balancers, cooling, lubrication and anti-corrosion agents comprising expelling said liquids from a disposable, universally available container using gas where the energy required to transfer the liquid to the tyre is derived from pressurising the space above said liquid in a PET vessel attached to the device.

11. A component of a kit, for instance to replace the spare wheel of a vehicle for the purpose of repairing tyres or the conferring of self-seal capability to tyres and improve the energy efficiency of a vehicle through weight reduction comprising a device according claims1 to 9

Application No:	GB1011932.9	**Examiner:**	Tim James
Claims searched:	1-11	**Date of search:**	12 October 2011

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-5 and 7-11	WO2004/041649 A1 (INTERDYNAMICS) see bottle 16 in figure 9, page 9 lines 7-20 and page 10 lines 12-19
X	1-3 and 7-11	US6766834 A (DUNLOP) see the figures and paragraph 0044
X	1-4, 10 and 11 at least	US2009/107578 A1 (TRACHTENBERG) see the figures and abstract
X	1-4, 10 and 11 at least	EP2090419 A1 (TRACHTENBERG) see the figures and abstract

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B29C

The following online and other databases have been used in the preparation of this search report

On-line: EPODOC, WPI, TXTE, TXTT

International Classification:

Subclass	Subgroup	Valid From
None		