relative to the handle as the appliance is moved along the user's teeth. The toothbrush is operable in a selected one of two different modes. In a first mode, the user depresses a button to actuate the delivery of working fluid from the nozzle. In a second mode, a controller actuates the delivery of working fluid to the nozzle automatically depending on a signal received from a sensor. The sensor is located in the handle of the toothbrush. A pivoting arm located within the stem connects the nozzle to a magnet located adjacent to the sensor and which moves relative to the sensor as the nozzle moves relative to the handle, for example as the nozzle moves into, or out from, an interproximal gap in the user's teeth.

SUMMARY ~~OF THE INVENTION~~

In a first ~~aspect~~example, the present ~~invention~~disclosure provides a dental treatment appliance comprising:

a handle;

an optical system comprising illuminating means for illuminating an oral cavity of a user, and image capturing means for capturing an image of the illuminated oral cavity;

a dental treatment system for delivering a treatment to the oral cavity; and

moving means for moving the illuminating means relative to the handle;

wherein the moving means is configured to move the illuminating means relative to the handle at a first frequency F1, and the illuminating means is configured to illuminate the oral cavity at a second frequency F2 to generate a plurality of illumination events each second.

In one aspect, the present disclosure refers to a dental treatment appliance comprising:

a handle;

an optical system comprising illuminating means for illuminating an oral cavity of a user, and a window for receiving light from the illuminated oral cavity, and from which the received light is conveyed to image capturing means for capturing images of the illuminated oral cavity;

a dental treatment system for delivering a treatment to the oral cavity in dependence on one or more features contained in the captured images; and

moving means for moving the illuminating means and the window relative to the handle;

wherein the moving means is configured to move the illuminating means and the window relative to the handle at a first frequency F1, and the illuminating means is configured to illuminate the oral cavity at a second frequency F2 to generate a plurality of illumination events each second.

Unlike the appliance described in WO2016/185154, the treatment of the oral cavity of the user is actuated in dependence on one or more of the features contained in the captured image of the oral cavity. For example, the captured image may include a region of plaque in the oral cavity, an interproximal region between adjacent teeth of the oral cavity or a gum line separating teeth from gum. The dental treatment system preferably comprises a controller which determines from the captured image whether treatment of the oral cavity is required, for example, using neural network models stored in its memory. The treatment of the oral cavity may be actuated by the controller and

may comprise, for example, the ejection of fluid into the interproximal region to remove matter located therein, the removal of plaque from the teeth of the user, or the irrigation of the gum line, as appropriate.

During a treatment of the oral cavity, the illuminating means of the optical system is moved relative to the handle. The illuminating means may be moved along a path of any desired shape relative to the handle. In a preferred ~~embodiment~~example, the moving means is arranged to move the illuminating means reciprocally relative to the handle, preferably along a curved path, more preferably along an arcuate path. The moving means is preferably arranged to move the illuminating means relative to the handle along a path which is arranged substantially perpendicular to a longitudinal axis of the handle. In a preferred ~~embodiment~~example, the illuminating means is reciprocally swept about the longitudinal axis of the handle by an angle in the range from 10 to 30 , preferably at a frequency F1 in the range from 200 to 300Hz. In a preferred ~~embodiment~~example, the frequency F1 of the oscillation of the illuminating means is 250Hz.

The illuminating means preferably comprises one or more light emitting diodes (LEDs). The illuminating means is preferably selected to emit visible light, more preferably selected to emit white light, preferably having a colour temperature in the range of 3,000 to 7,000K.

The optical system comprises a window for receiving light from the oral cavity, and from which light is conveyed to the image capturing means. The window of the optical system is preferably arranged to move with the illuminating means. The window is preferably located adjacent to the LEDs. The LEDs may be arranged about the window. The window may be in the form of a flat transparent panel, formed from glass or a plastics material, or it may be in the form of a curved transparent member so as to provide a lens of the optical system.

The image capturing means may be arranged to move with the illuminating means relative to the handle. For example, the appliance may comprise a stem extending

between a head and a handle, and the image capturing means may be located in either the stem or the head of the appliance so as to move with the illuminating means and the window relative to the handle. Alternatively, the image capturing means may be located in the handle, with light being conveyed from the window to the image capturing means through the stem of the appliance.

The image capturing means is preferably configured to capture a number N of images, or frames, per second. For example, the image capturing means may be arranged to capture 20 to 30 images, or frames per second, with an exposure time per frame in the range from 30 to 40msec. If the oral cavity were to be illuminated continuously, the movement of the illuminating means relative to the handle at a frequency in the range from 200 to 300 Hz during image capture would result in the generation of a blurred image. Such an image can be detrimental to the accuracy with which a controller can identify features such as plaque or an interproximal gap within the captured image, and so be detrimental to the accuracy of the treatment of the oral cavity by the appliance.

Through pulsing the illumination of the optical cavity at a frequency F2, we have found that the sharpness of the captured image can be improved in comparison to a situation where the oral cavity is illuminated continuously by the illuminating means, which can improve the accuracy of the treatment of the oral cavity.

The illuminating means may be activated once per oscillation cycle. In other words, the illuminating means may be configured to illuminate the optical cavity at a frequency F2, where F2=F1. In one ~~embodiment~~example, the illuminating means illuminates the optical cavity at a frequency F2 of 250Hz, and so there are 250 pulsed illuminations of the oral cavity, or “illumination events”, each second. The illuminating means is preferably activated at the aforementioned reference position.

The intensity or the duration of each illumination event may be varied depending on the ambient light intensity. For example, the appliance may comprise a sensor for measuring the ambient light intensity, and wherein a controller may be arranged to vary

at least one of the intensity and the duration of each illumination event depending on the measured ambient light intensity, for example, so that the intensity of the illumination of the oral cavity is relatively constant.

The moving means is preferably arranged to move the illuminating means towards and away from at least one reference position. For example, where the illuminating means is moved in a reciprocally sweeping movement along a curved path, a reference position may be located at the centre of that path. Alternatively, or additionally, reference positions may be located midway between the centre and the extremities of that path.

The image capturing means may be in the form of a global shutter camera, in which all of the pixels of the sensor of the camera are exposed simultaneously and for the same period of time during the time taken to capture an image, for example 25msec when the camera is operating at an image capture rate of 40 frames per second. However, in a preferred ~~embodiment~~example the image capturing means is in the form of a rolling shutter camera, in which the sensor of the camera is exposed in a progressive manner to capture an image. As is known, the sensor is divided into a number of rows and columns of pixels. During image capture, each row (or column) of pixels is exposed for the same period of time, and within each row all of the pixels are exposed for the same period of time. In this type of camera, exposure of the rows of pixels is sequential, in that the instant at which exposure starts and ends is slightly different for each row.

Banding effects are formed by alternating groups of dark and light rows of pixels. We have found that the bands stay in the same position during the acquisition of a sequence of images if the frequency F2 is an integer multiple of the frame rate of the camera. To inhibit the formation of banding effects in the captured image of the oral cavity, each row of pixels is preferably exposed to the same number of illumination events. The start time at which each row of pixels are exposed is preferably selected so that each row of pixels is exposed to the same number of illumination events to inhibit banding.

In a second ~~aspect~~example, the present ~~invention~~disclosure provides a dental treatment appliance comprising:

a handle;

an optical system comprising illuminating means for illuminating an oral cavity of a user, and image capturing means for capturing an image of the illuminated oral cavity;

a dental treatment system for delivering a treatment to the oral cavity; and

moving means for moving the illuminating means relative to the handle;

wherein the moving means is configured to move the illuminating means relative to the handle at a first frequency F1, and the illuminating means is configured to illuminate the oral cavity at a second frequency F2 to generate a plurality of illumination events each second, and wherein the image capturing means comprises a rolling shutter camera having a sensor comprising a plurality of rows of pixels, the rows of pixels being exposed sequentially, and wherein each row of pixels is exposed to the same number of illumination events.

When the user holds the handle of the appliance at a fixed position relative to the oral cavity, the images captured by the camera appears stationary with time when the frequency F2 of the illumination of the optical cavity is the same as the frequency F1 of the movement of the illuminating means relative to the handle. Depending on the distance between the camera and teeth being imaged by the optical system, this can result in a relatively narrow field of view of the camera, which, depending on the position of the appliance within the oral cavity, could prevent some treatable features of the oral cavity from being captured.

As an alternative to synchronizing the illumination of the oral cavity with the movement of the illuminating means, the appliance may be configured such that the frequency F2 of the illumination of the optical cavity is different from the frequency F1 of the movement of the illuminating means relative to the handle. By desynchronizing the illumination of the optical cavity from the movement of the illuminating means, the image captured by the camera can appear to move, in slow motion, relative to the

handle, and thus relative to the oral cavity, even when the user holds the handle of the appliance at a fixed position relative to the oral cavity. This can increase the effective field of view of the camera, and so increases the likelihood that any treatable feature within the oral cavity will be detected from the images captured by the camera.

The frequency F2 is preferably selected such that $0<|F1 - nF2|<N$, where N is the number of images captured per second by the image capturing means, and n is a positive integer selected such that $|F1 - nF2|$ has a minimum value. For example, where F1=250Hz and N=25 frames per second, with n=1 F2 may be selected from values between 225 and 275Hz.

In a third ~~aspect~~example, the present ~~invention~~disclosure provides a dental treatment appliance comprising:

a handle;

an optical system comprising illuminating means for illuminating an oral cavity of a user, and image capturing means for capturing an image of the illuminated oral cavity;

a dental treatment system for delivering a treatment to the oral cavity; and

moving means for moving the illuminating means relative to the handle;

wherein the moving means is configured to move the illuminating means relative to the handle at a first frequency F1, and the illuminating means is configured to illuminate the oral cavity at a second frequency F2 selected such that $0<|F1 - nF2|<N$, where N is the number of images captured per second by the image capturing means, and n is a positive integer selected such that $|F1 - nF2|$ has a minimum value.

The appliance may be in the form of an appliance for treating an oral condition of the user. For example, the appliance may be in the form of a dedicated interproximal cleaning appliance for cleaning between the gaps in the user's teeth. The treatment system may comprise a fluid delivery system for delivering working fluid to the oral cavity of the user. Depending on the image captured by the optical system, the treatment system actuates the delivery of working fluid to the oral cavity to dislodge matter

tool, or stem, preferably comprises a plurality of bristles. The bristles are preferably arranged around the nozzle, and may be arranged circumferentially about the nozzle. A plurality of bristles may be attached to a static section of the cleaning tool, which section is not moveable relative to the handle. Alternatively, or additionally, a plurality of bristles may be attached to a moveable section of the cleaning tool, which section is moveable relative to the handle.

In a preferred ~~embodiment~~example, the appliance comprises a brush unit comprising a bristle carrier and a plurality of bristles mounted on the bristle carrier, with the bristle carrier being moveable relative to the handle. The bristle carrier is preferably located on the head of the appliance. The appliance comprises a drive mechanism for driving the movement of the bristle carrier relative to the handle. The drive mechanism preferably comprises a transmission unit connected to the bristle carrier, and a drive unit for driving the transmission unit to move the bristle carrier relative to the handle. The drive unit is preferably located in the handle.

The drive mechanism is preferably arranged to drive the movement of the illuminating means relative to the handle. The illuminating means is thus preferably arranged to move with the bristle carrier relative to the handle. The illuminating means may be arranged to move relative to the handle with the same movement pattern as, or with a different movement pattern from, the bristle carrier. For example, the illuminating means, the window and the bristle carrier may be arranged to move reciprocally in a sweeping movement relative to the handle. The illuminating means and the window may be spaced from the bristle carrier, or at least one of the illuminating means and the window may be mounted on the bristle carrier. For example, the drive mechanism may be arranged to move the stem relative to the handle so as to move the brush unit, the illuminating means and the window simultaneously relative to the handle.

The nozzle is preferably arranged to move with the illuminating means relative to the handle. For example, the illuminating means and the nozzle may be mounted on or

tool to the handle. The cleaning tool contact is preferably located within the recess, and preferably protrudes inwardly from an internal peripheral surface of the recess to engage the handle contact when the cleaning tool is attached to the handle. A wire, track or other conductive member extends between the cleaning tool contact and the detecting means to convey signals from the detecting means to the cleaning tool contact.

In addition to extending along part of the transmission unit, the transmission path preferably also extends along part of the drive unit. The drive unit preferably comprises means for engaging the shaft, and the engaging means is preferably arranged to convey signals towards the controller. The drive unit is preferably arranged to move, more preferably rotate, the shaft away from an equilibrium position to move the cleaning tool relative to the handle against the force of the engaging means. The engaging means is arranged to urge the shaft back towards its equilibrium position when the driving force of the drive unit is removed. The engaging means may comprise a spring member, and in a preferred ~~embodiment~~example comprises a torsion spring. A wire, track or other conductive member extends between the spring member and the controller to convey signals from the spring member to the controller.

As mentioned above, the dental treatment system preferably comprises a fluid delivery system for delivering a working fluid to the oral cavity of the user. The fluid delivery system preferably comprises a fluid reservoir and a pump, with the controller being arranged to actuate the pump to draw working fluid from the fluid reservoir and eject working fluid towards the nozzle. The controller is preferably arranged to actuate the pump to eject a burst of working fluid towards the nozzle. The volume of each burst of working fluid which is generated by the fluid delivery system is preferably less than 1 ml, more preferably less than 0.5 ml. In a preferred ~~embodiment~~example, the volume of the burst of working fluid generated by the fluid delivery system is in the range from 0.05 to 0.4 ml. The fluid delivery system is preferably configured to deliver a burst of working fluid to the nozzle at a static pressure in the range from 3 to 10 bar.

The transmission unit preferably defines part of the fluid delivery system. The shaft preferably comprises a bore which defines part of the fluid delivery system.

The appliance preferably comprises a user interface for enabling a user to select a mode of operation of the appliance before the commencement of a treatment process. The user interface may be located on the handle of the appliance, and preferably comprises at least one user operable switch or button. The user interface may comprise a display located on the handle for displaying information about a chosen operating mode. Alternatively, the appliance may be connected wirelessly to a remote device having a display for displaying that information. The remote device may be in the form of a dedicated display or a personal device. The remote device may also include a user interface, such as a touch sensitive display, for enabling a user to select an operating mode for the appliance.

Features described above in connection with the first aspect of the ~~invention~~disclosure are equally applicable to the second or third aspect of the ~~invention~~disclosure, and vice versa.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred features of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1(a) is a perspective view, from the front, of a dental cleaning appliance, and Figure 1(b) is a perspective view, from the rear, of the appliance of Figure 1(a);

Figure 2(a) is a side view of a brush unit of the appliance of Figure 1(a), Figure 2(b) is a perspective view of the brush unit with some of the bristles omitted to reveal a sensor and nozzle of the brush unit, and Figure 2(c) is a sectional view taken along line A-A in Figure 2(a); and

Figure 3 is a schematic illustration of a fluid delivery system of the appliance;