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(72) Inventor; and

(71) Applicant : **POGORELSKY, Yan** [US/US]; #1 Sorento Court, Miller Place, NY 11764 (US).

(74) Agents: **ELLIS, Edward, J.** et al.; Leason Ellis LLP, 81 Main Street, Suite 503, White Plains, NY 10601 (US).

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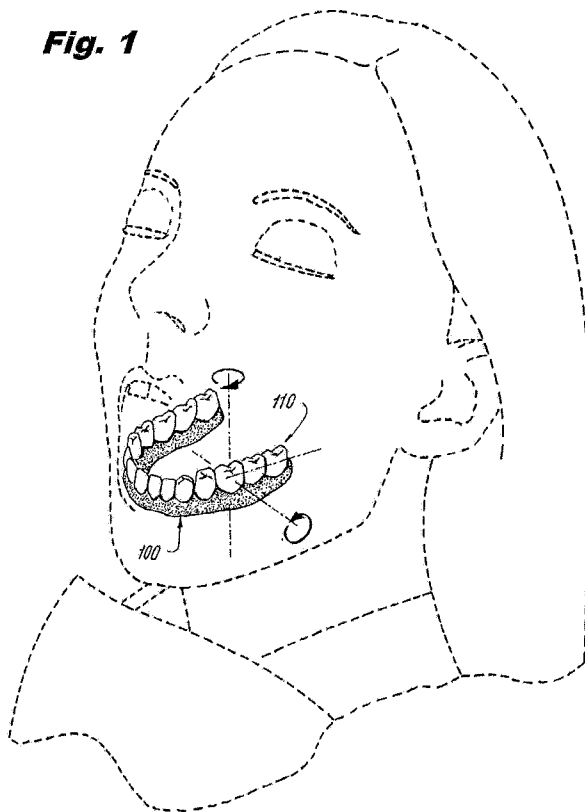
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(54) Title: SYSTEM AND METHOD FOR ALIGNING TEETH

**Fig. 1**



(57) Abstract: A dowel pin and sleeve combination for use with a tooth die that is part of a dental model includes a dowel pin and a sleeve that receives the pin. The dowel pin includes a tooth anchor section that is configured to be fixedly attached to the tooth die and a main body section having a bore formed therein. The main body section has a living hinge formed therein that partitions the main body section into an upper pivotable portion that pivots about the hinge and a lower portion. A section of the bore is threaded and the main body section includes an urging member that travels along the threaded bore section and can be driven into contact with the pivotable portion of the main body section. The bore forms an entrance into the slot that defines the living hinge to permit the urging member to be driven into contact with the pivotable portion. The pin includes a locating member extending radially outward from the main body section. The locating member is shaped to indicate a pivot direction of the tooth die and therefore a direction of intended tooth movement. The sleeve is for fixation in a base of the model and has a central bore formed therein that is configured to receive the pin.

## SYSTEM AND METHOD FOR ALIGNING TEETH

Cross Reference to Related Application

The present application claims priority to U.S. Patent Application No. 12/632,356,  
5 filed December 7, 2009, which is a continuation-in-part of U.S. patent application serial No.  
12/612,794, filed November 5, 2009, each of which is hereby incorporated by reference in its  
entirety.

Technical Field

The present invention relates to orthodontics and in particular, the present invention  
10 relates to a system and method for incrementally moving one or more teeth from an initial  
tooth arrangement to a final tooth arrangement.

Background

Orthodontics is a specialty of dentistry that is concerned with the study and treatment  
of malocclusions (improper bites) which can be a result of tooth irregularity, disproportionate  
15 jaw relationships, or both. Orthodontic treatment can focus on dental displacement only and  
can be carried out for purely aesthetic reasons with regard to improving the general  
appearance of patient's teeth. However, there are other orthodontic treatments that are more  
complex and are needed to reconstruct the face. This type of treatment is most often  
prescribed for practical reasons such as providing the patient with a functionally improved  
20 bite (occlusion).

Conventionally, repositioning teeth for aesthetic reasons or other reasons is accomplished by wearing a device that is commonly referred as dental braces. Dental braces are formed of a variety of appliances such as brackets, archwires, ligatures, and O-rings.

Attaching dental braces to the teeth of a patient is a tedious, time consuming task that

5 requires a number of meetings between the patient and orthodontist to first prepare and fit the dental braces and then make necessary adjustments to the dental braces. Before the braces are fixedly attached to the patient's teeth, various molds and fittings are required in order to formulate the strategy. To attach the braces, a weak acid is first applied to the teeth to increase the adherence of the braces to the teeth. Brackets and bands that form the dental  
10 braces are bonded to the patient's teeth using cement. The primary force-inducing appliance in a conventional set of braces is the archwire. The archwire is resilient and is attached to the brackets by way of slots in the brackets. The archwire links the brackets together and exerts forces on them to move the teeth over time. After the archwire is in place, periodic meetings with the orthodontist are required and during these meetings, the patient's  
15 braces are adjusted by installing a different archwire having different force-inducing properties or by replacing or tightening existing ligatures.

Besides being a time consuming process, conventional braces are also very unsightly and are uncomfortable to wear to the presence of these components in the mouth, bonded to and extending across the teeth, etc.

20 In recent years, improvements in the field of orthodontistry have produced dental products that are alternatives to conventional braces. For example, a dental system available under the name "Invisalign®" is distributed by Align Technologies. This system involves a

process where, once a candidate is found to be suitable for wearing this type of product, impressions and pictures of the patient's teeth are taken. The teeth impressions are digitized and sent to the company to establish a plan for tooth movement over a treatment timeline which is typically 18 months. Based on a precise treatment plan, customized aligners are  
5 created for the patient to wear at each stage of the treatment. Typically, a full set of treatment includes 20-30 aligners per arch. The aligners are worn as much as possible, with the exception of eating and drinking, in order to complete the treatment within the timeline established with the patient.

The Invisalign® system is a computer based system in which not only are the imprints  
10 digitized and stored in memory but also the computer uses algorithms and the like to develop virtual correction steps (i.e., incremental changes in the teeth to be implemented over months or years). After the virtual correction steps are calculated, a sophisticated laser machining of multiple adjusters controlled by the same computer. Therefore, the production is expensive and a complete set of braces is made in advance and corrective interaction during the  
15 treatment process is practically not feasible.

The Invisalign® system is fairly costly to patients and also the plan is designed to be implemented over a long time period. As a result, the patients typically wear a particular aligner for a single month and due to the substantial number of aligners that are used, the process is implemented over a substantial number of months. For example, the patient is  
20 given a tray of about 20 aligners which are used by the patient over the next 20 successive months.

Due to certain limitations of the Invisalign® system, some of which are described herein, the course of treatment is spread out over many months as a result of the slight incremental changes that are incorporated into the aligners. For example, the Invisalign® system uses a laser incorporated as part of a vacuum forming machine that is used to heat and thereby form the aligner and, therefore, the thickness of the vacuum forming material is limited to thicknesses that can be processed with the laser without destroying the material. This imposes a limitation on the manufacturing process as well as the treatment time table that can be proposed to a patient.

While the Invisalign® system has merit, it would be advantageous to provide a system that is model that has a plurality of tooth dies is provided. At least one tooth die can be selectively adjusted to a new position to allow formation of an aligner that is intended to be worn on teeth of the patient. The model includes a first model part that is formed of a plurality of tooth dies and a second model part complementary to the first model part and being in the form of a base that supports the tooth dies. The model further includes a dowel pin and sleeve combination for use with the tooth die that is intended to be adjusted. The combination includes a dowel pin including a tooth anchor section that is configured to be fixedly attached to the tooth die and a main body section having a bore formed therein and open at one end of the pin. The main body section has a slot that defines a living hinge formed therein that partitions the main body section into an upper pivotable portion that pivots about the hinge and a lower portion. A section of the bore is threaded and the main body section includes an urging member that travels along the threaded bore section and can be driven into contact with the pivotable portion of the main body section. The bore forms an

entrance into the slot that defines the living hinge to permit the urging member to be driven into contact with the pivotable portion. The pin also includes a gear section that is located at an end of the main body section opposite the tooth anchor section. The gear section has teeth with the bore extending through the gear section so as to be open at the one end of the pin.

5 The combination also includes a sleeve for fixation in a base of the model. The sleeve has a central bore formed therein that is configured to receive the pin and permit the pin to be rotated therein. The central bore includes a longitudinal locating and locking rail formed therein. The rail has dimensions that permit it to lockingly engage the teeth of the gear section.

10 The tooth die is pivotable about the living hinge and can be rotatable relative to the sleeve.

The physical 3-D model of the patient's teeth allows the orthodontist to individually adjust those tooth dies that require adjustment as part of the treatment plan. The model is used in combination with conventional dentist equipment (e.g., vacuum forming equipment)

15 to construct aligners that are used to adjust the patient's tooth in an incremental manner from an initial tooth arrangement to a desired, final tooth arrangement. The present system provides a number of advantages and a degree of customization not available with the conventional computer-based systems.

### Summary

20 According to one embodiment, a dowel pin and sleeve combination for use with a tooth die that is part of a dental model includes a dowel pin and a sleeve that receives the pin.

The dowel pin includes a tooth anchor section that is configured to be fixedly attached to the tooth die and a main body section having a bore formed therein. The main body section has a living hinge formed therein that partitions the main body section into an upper pivotable portion that pivots about the hinge and a lower portion. A section of the bore is threaded and the main body section includes an urging member that travels along the threaded bore section and can be driven into contact with the pivotable portion of the main body section. The bore forms an entrance into the slot that defines the living hinge to permit the urging member to be driven into contact with the pivotable portion. The pin includes a locating member extending radially outward from the main body section. The locating member is shaped to indicate a pivot direction of the tooth die and therefore a direction of intended tooth movement. The sleeve is for fixation in a base of the model and has a central bore formed therein that is configured to receive the pin.

These and other aspects, features and advantages shall be apparent from the accompanying Drawings and description of certain embodiments of the invention.

#### Brief Description of the Drawings

Fig. 1 illustrates a patient's jaw and provides a general indication of how teeth can be moved in accordance with the system and method of the present invention;

Fig. 2 illustrates the jaw of Fig. 1 with an incremental position adjustment device that has been configured for placement over the teeth to cause over time incremental movement of the teeth;

Fig. 3 is a top perspective view of an adjustable dental model in accordance with the present invention showing a tooth die(s) portion and a base portion;

Fig. 4 is an exploded perspective view of a dowel pin assembly in accordance with the present invention;

5        Fig. 5A shows the dowel pin fixedly attached to a tooth die with the living hinge in a first orientation relative to the tooth die;

Fig. 5B shows the dowel pin fixedly attached to a tooth die with the living hinge in a first orientation relative to the tooth die;

10       Fig. 6 is an exploded view of one exemplary dowel pin assembly according to one embodiment;

Fig. 7 is an exploded view of an exemplary dowel pin assembly according to another embodiment;

Fig. 8 is a perspective view of a dowel pin according to another embodiment of the present invention;

15       Fig. 9 is a side elevation view of the dowel pin of Fig. 8;

Fig. 10 is a perspective view of the dowel pin of Fig. 8 in combination with a sleeve;

Fig. 11 is a cross-sectional view of the sleeve of Fig. 10;

Fig. 12 is side perspective view of an adjustable dental model in accordance with another embodiment of the present invention showing a tooth die(s) portion and a base portion;

Fig. 13 is an end perspective view of the model of Fig. 12;

5 Fig. 14 is a top perspective view showing the tooth pie portions exploded from a base portion; and

Fig. 15 is a cross-sectional view taken along the line 15-15 of Fig. 12.

#### Detailed Description of Certain Embodiments of the Invention

In accordance with one embodiment of the present invention, systems and methods  
10 are provided for incrementally moving one or more teeth using a plurality of discrete members (aligners) that successively move one or more teeth by predetermined amounts. The system is configured so that the tooth movements are those normally associated with orthodontic treatment, including translation in all three orthogonal directions relative to a vertical centerline, rotation of the tooth centerline in the two orthodontic directions (“root  
15 angulation” and “torque”), as well as rotation about the centerline. These movements are shown in Fig. 1.

As described herein and in contrast to the computer-based systems of the conventional systems described above, the system and method of the present invention avoid the complexity of the computer-based systems and provide a more personal treatment plan that  
20 can be discussed and developed directly between the patient and his or her orthodontist. The

present invention generally is in the form of an adjustable dowel pin assembly that support tooth dies and are embedded into a physical 3-D model of the patient's teeth to allow the orthodontist to individually adjust those tooth dies that require adjustment as part of the treatment plan. The model is used in combination with conventional dentist equipment (e.g., vacuum forming equipment) to construct aligners that are used to adjust the patient's tooth in an incremental manner from an initial tooth arrangement to a desired, final tooth arrangement. The present system provides a number of advantages and a degree of customization not available with the conventional computer-based systems.

Fig. 1 shows a representative jaw 100 that includes sixteen teeth 110. The present invention is intended to move at least some of these teeth 110 from an initial tooth arrangement to a final tooth arrangement.

Fig. 2 is a perspective view of a discrete member or apparatus (teeth positioner or aligner) 200 that is part of the system of the present invention and is intended to cause the movement of one or more teeth. In order to move the one or more target teeth from the initial tooth arrangement to the final tooth arrangement, one to a plurality of aligners 200 are used over a prescribed period of time determined by the orthodontist. Each aligner is intended to effect incremental repositioning of individual teeth in the jaw as described above. When plural aligners 200 are created for a given patient, they are intended to be worn successively by the patient in order to achieve gradual tooth repositioning as described below in greater detail. An exemplary aligner 200 is formed of a polymeric shell that has a cavity 202 shaped to receive and resiliently reposition teeth from one tooth arrangement to a successive tooth arrangement. Typically, the polymeric shell fits over all teeth present in the upper or lower

jaw; however, this is not an absolute requirement and other arrangements are possible. Many times, only certain teeth are repositioned while other teeth will provide a base or anchor region for holding the aligner 200 in place as it applies the resilient repositioning force against the tooth or teeth to be repositioned.

5           The aligner 200 is formed from a sheet of a suitable elastomeric polymeric and more particularly, the aligner 200 is formed from a sheet of dental material. For example, the aligner can be formed a vacuum forming material that is used in the dental field and is available from a number of different commercial suppliers. In one embodiment, the aligner is formed of a vacuum forming material that is available is sheets of varying thicknesses from  
10   Henry Schein. For example, the sheets of vacuum forming material can come in thicknesses of 0.60", 0.80", .10" and 0.12". It will be appreciated that that these sheet thicknesses are substantially greater than the 0.02" thickness of the material that is used to form the dental appliances used in the Invisalign® system, and as such are more rigid and so they are able to impact a greater movement of teeth than possible using a thinner aligner such as in the  
15   Invisalign® system.

As described in detail below, the aligner 200 is intended to be worn over teeth without for wires or other attachment means being used and instead, the aligner 200 is constructed to hold the aligner 200 in place over the teeth without such external assistance.

Now referring to Figs. 2—4, an exemplary system and method of the present  
20   invention are shown.

In accordance with one embodiment of the present invention, a dental impression of the patient's teeth is first formed. As is known in the art, a dental impression is an accurate representation of part or all of a person's dentition and other areas of the mouth. From an imprint of a person's teeth and gums in wax or plaster, a dental impression forms a

5 "negative" of those teeth and gums. The negative is then used to make a cast or model 250 of the dentition, which is also called a die and represents a positive replica of the tooth or teeth. An exemplary model 250 is shown in Fig. 3. The impression is carried out by placing a viscous liquid material into the mouth usually in a customized tray. The material then sets to become an elastic solid and when removed from the mouth retains the shape of the teeth.

10 Common materials used for dental impression are sodium alginate, polyether and silicones (both condensation-cured silicones and addition-cured silicones, such as polyvinyl siloxane.

After forming the model 250 of the patient's teeth in the initial tooth arrangement, it is often desirable and typically necessary to separate one tooth die 260 from the remainder of the model of the patient's mouth. Any number of conventional techniques can be used to

15 separate one tooth die 260 from the remainder of the model 250. For example, a cutting element can be used to separate each tooth die and in particular, the cutting element can be in the form of a mechanical cutting device, such as a saw, or it can be in the form of a laser that makes precise cuts. In order to permit the separated tooth die 260 to be replaced in its original relative position and orientation, the tooth dies 260 are provided with a dowel pin.

20 In accordance with the present invention, a device is used to form one or more openings in an underside of the tooth die in order to allow coupling of the dowel pin to the tooth die (not shown). For example, a pin indexing or pinsetter device can be used to locate

dowel pin openings. As is known, the pinsetter device offers precision die pinning featuring a laser light beam indicator for easier, more accurate dowel pin location. One exemplary pinsetting machine is commercially available from Coltene/Whaledent under the trade name Pindex Mark II Laser. The pinsetter device is thus used in the model and die fabrication process of the present invention and includes a small laser beak that makes drill hole positioning more accurate. It will thus be appreciated that the Pindex machine or the like is used to precisely drill holes in the model/die that permit each separated tooth die to be removed and replaced relative to the remained of the model.

After forming the openings (dowel pin holes) in the tooth die, a shank of the dowel pin is inserted into the respective pin opening formed in the tooth die and is secured thereto using conventional techniques. For example, an adhesive, bonding material or the like, can be used to secure the shank of the dowel pin to the tooth die. The shaft of the dowel pin extends below the underside of the tooth die.

The tooth die model 250 also includes a base 270 to which the tooth dies are removably coupled. The base 270 has a top planar surface 272 and a bottom planar surface 274 so that it can rest on a support surface, such as a table or the like. The base 270 includes metal sleeves 280 which has one or more openings 282 that receive the shafts of the pins to allow coupling between the tooth dies 260 and the base 270. The metal sleeve 280 includes openings that receive the shafts of the pin.

The base 270 is formed using conventional techniques and once the pin locations are determined and the pins are inserted into the tooth dies 260, the base 270 is formed around

the metal sleeves 280 and pin couplings. In this manner, the base 270 is complementary to the tooth dies 260 in that the pins of the tooth die 260 are received within complementary openings formed in the base 270 (e.g., the metal sleeves fixedly attached within the base). In this manner, the tooth dies 260 can be return to the base 270 and all the tooth dies 260 are  
5 maintained in their proper position despite being cut and being separate from adjacent tooth dies. Fig. 3 shows the base 270 containing a predetermined number of conventional metal sleeves 280 as well as sleeves that are made in accordance with the present invention as discussed below.

In accordance with the present invention, an adjustable dowel pin assembly 300 is  
10 provided and is best shown in Figs. 4 and 6. The adjustable dowel pin assembly 300 is intended to be used with a tooth die 260 (Fig. 3) that is associated with one or more teeth that are to be incrementally moved during the course of treatment. Fig. 6 is an exploded view of the dowel pin assembly 300.

Fig. 4 shows one exemplary dowel pin assembly 300 that is formed of two distinct,  
15 complementary parts. More particularly, the assembly 300 includes a pin 310 and a complementary sleeve 400. As described herein, a portion of the pin 310 is fixedly attached to the tooth die and another portion of the pin 310 that extends below the tooth die is for insertion into the sleeve 400 that is fixedly coupled to the base of the model.

The sleeve 400 is an elongated member that has a first end 402 and an opposing  
20 second end 404. The sleeve 400 is a hollow member and therefore includes a bore 410 formed therethrough. The bore 410 is open at both the first end 402 and the second end 404.

The sleeve 400 can have any number of different shapes. In the illustrated embodiment, the sleeve 400 has a hexagonal shaped outer surface; however, the bore 410 can have a different shape and in the illustrated embodiment, the bore 410 is circular shaped. In accordance with the present invention, the sleeve 400 has a locating and coupling element 420 that is formed  
5 within the bore 410. The coupling element 420 is in the form of a rail that runs the length of the bore 410 from the first end 402 to the second end 404. More specifically, as shown in Fig. 4, the coupling element 420 is in the form of a pair of rails 420 that are located opposite one another (180 degrees apart).

The pin 310 is likewise an elongated structure that has a first end 312 and an opposing  
10 second end 314 with the first end 312 being the end that is fixedly coupled to the tooth die and the second end 314 being the end that is coupled to the sleeve 400. The pin 310 is actually formed of a number of distinct sections, namely a tooth anchor section 320, a main body 330 and a gear section 380. The tooth anchor section 320 is located at the first end 312, the gear section 380 is located at the second end 314 and the main body 330 is an  
15 intermediate section located between the two other sections.

The tooth anchor section 320 represents the portion of the pin 310 that is inserted into the drill hole formed in the underside of the tooth die and therefore the tooth anchor section 320 is received within the tooth die and fixedly attached thereto. The tooth anchor section 320 can have a contoured or modified outer surface 322 to assist in fixedly attaching the pin  
20 310 to the tooth die. For example, the outer surface 322 can be serrated or can have other surface modifying structures. In the illustrated embodiment, the outer surface 322 is a ribbed

surface formed of a plurality of vertically oriented ribs (e.g., ribs that run longitudinally along the length of the tooth anchor section 320.

The tooth anchor section 320 can have any number of different shapes; however, the shape of the tooth anchor section 320 is complementary to the shape of the drill hole since the  
5 tooth anchor section 320 is received within the drill hole. In the illustrated embodiment, the tooth anchor section 320 has a cylindrical shape.

The anchor section 320 extends beyond the main body section 330 and therefore represents a post or the like. The anchor section 320 is preferably a solid structure to increase the integrity and strength of the connection between the pin 310 and the tooth die.

10 The main body section 330 is not a solid structure but rather the main body section 330 has a bore 332 formed therein. The main body section 330 can have any number of different shapes; however, the shape of the main body section 330 is complementary to the shape of the bore 410 formed in the sleeve 400 since at least a portion of the main body section 330 is disposed within the sleeve 400. In the illustrated embodiment, the main body  
15 section 330 has a cylindrical shape. In addition, the width (diameter) of the main body section 330 is greater than the width (diameter) of the tooth anchor section 320. As a result, a shoulder 325 is formed between one end of the main body section 330 and the tooth anchor section 320. The shoulder 325 has an annular shape. Optionally, the tooth anchor section 320 can be bonded as by an epoxy or cement to a tooth with the bond being between the tooth  
20 and the shoulder 325.

In accordance with the present invention, the main body section 330 has a living hinge 340 formed therein. The living hinge 340 is located proximate the end of the main body section 330 that interfaces with the tooth anchor section 320. The living hinge 340 is thus in the form of a cut or slot 342 that is formed in main body section 330. This slot 342 partitions the main body section 330 into a first part 344 that is located above the slot and extends toward the tooth anchor section 320 and a second part 346 that is located below the slot and extends toward the gear section 380. The living hinge 340 allows for relative movement between the first and second parts 344, 346. The slot 342 is thus a wedged shaped cut.

The main body section 330 has the bore 332 formed therein. The bore 332 extends along the longitudinal axis of the main body section 330. The bore 332 is open at one end of the pin 300, while the other end of the bore 332 forms an entrance into the slot 342. In other words, the bore 332 is open and accessible at the end of the pin 300 that includes the gear section 380. The bore 332 itself can have any number of different shapes and in the illustrated embodiment, the bore 332 has a circular or hexagonal shape. At least a portion 335 of the bore 332 is in the form of a threaded bore. In other words, a section 335 of the bore 360 is threaded. The section 335 is formed at one end of the bore 332 and in particular, the section 335 is formed at the end of the bore 332 that forms an entrance into the slot 342.

The main body section 330 also includes an urging member 375 that is located within the bore 332 and is designed to travel along the threaded section 335. In one embodiment, the urging member 375 is in the form of an urging screw that is located within the bore. The urging screw 375 has external threads that are complementary to the threaded section 335 and

therefore, the urging screw 375 threadingly mates with and travels along the threaded section. The urging screw 375 thus has a complementary shape relative to the bore 332 and in particular, the threaded section 335 and therefore, in one embodiment, the urging screw 375 has a circular or hexagonal shape.

5           The gear section 380 can be formed at one end of the pin 310. The gear section 380 is intended to act as a gear to permit rotation of the pin 310 relative to the sleeve 400 as described below. The gear section 380 has a size and shape that is complementary to the shape and size of the bore 410 formed in the sleeve. In the illustrated embodiment, the gear section 380 has a cylindrical shape and includes a flared flange (annular flange) 385 formed  
10   at the end 314 of the pin 310. An outer surface of the gear section 380 serves as a gear and accordingly, the outer surface of the gear section 380 is defined by a plurality of teeth 382. The teeth 382 are defined by a plurality of spaced, vertically oriented ribs that extend about the circumference of the gear section 380. Along with a side wall of the pin, the flange 385 includes the teeth 382. The flange 385 thus represents a slotted annular flange.

15           The teeth 382 are configured to mate with the coupling element 420 of the sleeve 400. In particular, the dimensions (width) of the coupling element 420 are about equal to the spacing between the teeth 382 and therefore, the coupling element 420 is intimately received within the spacing between the teeth 382. When first inserting the pin 310 into the sleeve, the two rails 420 are aligned and guided into respective spaces between teeth 382 of the flange  
20   385. It will be appreciated that the outer peripheral edge of the flange 385 contacts and seats against the inner surface of the bore 410 of the sleeve 400. The flange 385 serves to stabilize the pin 310 within the bore 410 of the sleeve 400.

The materials used to form the teeth 382 and the coupling elements 420 are resilient enough that when the coupling elements 420 are received within the space between adjacent teeth 382 and the pin 300 is rotated relative to the fixed sleeve 400, the pin 300 moves a predetermined amount due to the teeth 382 moving relative to the fixed coupling elements (rail) 420. An audible “click” can be heard to indicate that the pin 300 has moved one rotational position.

In one embodiment, the spacing of the teeth 382 and the dimensions of the rails 420 are such that one rotation of the pin 310 results in a 2° rotation of the pin 310 relative to the sleeve 400. It will be appreciated that due to the close proximity of adjacent teeth in a patient’s jaw, during the course of a normal orthodontic treatment, a tooth is unlikely to be rotated more than 16°. It will be understood that the above incremental degrees of change are merely exemplary and the teeth can be configured so that each rotation results in a different degree of change. As a result, the gear section 380 can be formed to only include 8 incremental rotational movements. In other words, the teeth 382 do not have to be formed around the entire circumference but can be limited to less than the entire circumference to limit the degree of rotational movement of the pin 310 relative to the sleeve 400. The number of teeth 382 can be limited so that the pin 310 cannot be rotated more than, say, 16° relative to the sleeve 400.

Since the tooth anchor section is fixedly attached to tooth die, rotation of the tooth die is directly translated into rotation of the pin 310 relative to the sleeve 400.

Since the rails 420 extends the entire length of the bore 410 of the sleeve 400, the pin 310 is inserted into the bore 410 by aligning the rail 420 with one space formed between the teeth 382 and then slidingly moving the pin 310 within the bore 410 of the sleeve 400 until the gear section 380 is located at or near the end of the sleeve 400 to permit access to the bore 332 formed in the pin 310 at the end of the sleeve 400. In other arrangements the teeth 382 can be located intermediate the ends of the pin 310. Also the teeth can comprise recesses that cooperate with complementary structure within the bore 410 of the sleeve 400.

As with conventional dowel pins, the sleeve 400 is fixedly attached to the base of the model and the individual tooth dies are simply removably coupled to the base by inserting the pin 310 into the sleeve 400. Fig. 3 shows the base 270 including a combination of conventional sleeves 280 and sleeves 400 made in accordance with the present invention. In this manner, the sleeves 280 receive standard dowel pins, while the sleeves 400 are used with the pins 310 of the present invention that are designed to allow the tooth die to be moved by the orthodontist to a new position.

The operation of the assembly 300 is now described. Once the tooth anchor section 320 is fixedly attached to the tooth die, the tooth die can be moved in a number of different directions by manipulation of the assembly 300. For example and as shown in Fig. 1, if it desired to move the tooth die in one or more directions indicated in Fig. 1 (e.g., a forward/rearward movement of the tooth), the pin 310 is fixedly attached to the tooth die such that the living hinge 340 opens in this same direction as the desired movement of the tooth die. If the tooth die is desired to move in left-to-right movement, then the pin 310 is simply attached to the tooth die with the living hinge 340 opening in this left-to-right direction. It

will therefore be appreciated that the tooth die can be moved in any number of different directions to accommodate the tooth movements that are normally encountered in orthodontic treatments. Figs. 5A and 5B shows two different orientations of the pin 310 relative to the tooth die 260. In particular, Fig. 5A shows the living hinge 340 oriented to open in a right-to left manner as shown in the figure sheet, while Fig. 5B shows the hinge 340 opening in direction out of the page of the drawing sheet. Advantageously, after adjustment of the tooth die, it remains in the new position which allows a new aligner to be created.

A tool 500 is provided for engaging the urging screw 375. For example, a small Allen wrench type tool can be provided for insertion into the bore 332 and for mating with the urging screw 375. Rotation of the tool 500 causes rotation of the urging screw 375 resulting in the urging screw traveling along the threaded section 362 (whether the urging screw is driven toward or away from the tooth die depends on which direction the tool is rotated). To cause movement of the tooth die, the urging screw 375 is driven along the threaded section 362 until the urging screw 375 enters the slot 342 of the living hinge 340 and comes into contact with the underside of the first part 344 that is located above the slot 342. It will be appreciated that continued movement of the urging screw 375 caused an upward force to be applied to the first part 344 and since the first part 344 is connected to the second part 346 by means of the living hinge 340, the first part 344 pivots about the living hinge 340 resulting in a pivoting of the tooth die that is attached to the tooth anchor 320 (which is directly connected to the first part 344).

The degree to which the urging screw 375 is driven into the slot 342 depends upon the degree of pivoting in the tooth die that is desired. Thus, depending upon the degree of

intended movement of the tooth die, the urging screw is driven a certain amount into contact with the

In other words, the angle that the hinge 340 opens correlates to the degree of movement of the tooth die. If the tooth die is only intended to pivot a small amount as in the case with a patient that only needs minor correction of the tooth position, then the living hinge 340 is only opened a small amount. Conversely, if the patient's tooth requires more severe movement, then the urging screw is driven to a greater degree to cause the living hinge 340 to open to a greater degree. The degree that the hinge 340 opens is controlled with precision by using the tool 500 to cause the urging screw to open the hinge 340 to the desired degree. If the hinge 340 is opened too much, the orthodontist simply has to rotate the tool in the opposite direction to cause the urging screw to back away from the first part 342.

It will further be appreciate that the tooth die can be rotated a predetermined number of degrees by simply grasping the tooth die and slowly rotating it until it assumes the desired position. Controlled rotation of the tooth die is made possible due to the coupling between the rail 420 and the gear section 380 and the resulting controlled rotation of the pin 310 relative to the sleeve 400. Audible clicking noises will be heard as the pin 310 is rotated.

As a result, the tooth die can be adjusted according to a number of different degrees of freedom using the pin assembly 300 of the present invention in place of a conventional dowel pin.

It will be appreciated that the pin 300 can be formed according to conventional techniques, such as injection molding using molds. When injection molding is used, the

urging member (urging screw) 375 is disposed within the mold and the pin structure is formed therearound. As a result, the urging member 375 is located within the bore 332. In addition, the tool 500 can be disposed within the mold so as to form a lower portion of the bore 332.

5           As a result of incorporating the pin assembly 300 into one or more of the tooth dies, the tooth dies that form a part of the model can be manually manipulated by the orthodontist to suggest and formulate an orthodontic treatment plan for a particular patient. As described above, by first setting the living hinge 420 in the correct position relative to the tooth die, the tooth die can be moved in increments until the tooth die assumes its final, desired position.

10           The sleeve 400 is fixedly attached to the base using conventional techniques and in one embodiment, the base is formed around the strategically placed sleeves 400. For example, the material that forms the base is introduced into a mold that has the sleeves 400 positioned therein. The material flows around the sleeves 400 and thus when it hardens, the sleeves 400 are securely held within the base at their proper locations.

15           Fig. 6 shows one exemplary pin assembly 390 in an exploded manner. The pin assembly 390 is similar to the pin assembly 300. However, in the pin assembly 390, the gear section 380 does not include a flared flange at its end and instead, the gear section 380 is simply defined by a plurality of teeth (in the form of fingers) that are defined by spaced slots formed circumferentially about the gear section 380. One tooth or finger is defined between  
20 a pair of slots. It will be appreciated that the outer diameters of the main body section and the gear section 380 are equal.

The sleeve 400 includes a complementary locking rail or wedge 495 that is formed along the inner surface of the bore 410 at the end of the sleeve 400. The locking rail 495 is sized and shaped so as to lockingly engage one space between adjacent teeth 382 as described above with reference to pin assembly 300.

5           As shown in Fig. 6, the pin assembly 300 can include a plug 450 that is constructed to intimately mate with the sleeve 400. The plug 450 has a post portion 452 and a base portion 454 with the post portion 452 extending outwardly from the base portion 454. The post portion 452 can be a hollow cylindrical shaped structure (e.g., a tube). The plug 450 (post portion 452) is inserted into the bore 410 of the sleeve 400. The plug 450 can be formed of  
10 any number of different materials including but not limited to polymeric materials and rubber. For example, the plug 450 can be in the form of a rubber plug (stopper) that is inserted into the bore 410 of the sleeve 400 to close off the sleeve 400. It is desirable to close off the bore 410 of the sleeve 400 during the formation of the base 270 when the base 270 is formed since it is not desirable for the material that forms the base 270 to enter the bore 410.  
15 If this material enters the bore 410 and hardens, it will obstruct the bore 410 and the operation of the pin.

The sleeve 400 also includes an extension 415 that extends beyond the end of the sleeve 400. The extension 415 has a tubular shape with a bore 417 that is axially aligned with the bore 415. In one embodiment, the bores 410 and 417 have substantially similar or  
20 identical inner diameters. The extension 415 is designed to receive the post portion 452 of the plug 450. It will be appreciated that absent this extension 415, the insertion of the plug 450 into the sleeve 410 will be prevented due to the presence of the rail/wedge 495. The

length of the extension 415 is thus approximately the same length of the post portion 452 of the plug 450.

Fig. 7 illustrates a pin assembly 600 according to another embodiment of the present invention. The pin assembly 600 is similar to the pin assembly 300. One difference between the pin assembly 600 and the pin assembly 300 is that in the pin assembly 600, the pin itself is not controllably rotated as in the pin assembly 300. The pin assembly 600 is formed of a pin 610 and a sleeve 700. The pin 610 is similar to pin 310 and includes a tooth anchor portion 620 and a main body portion 630. The tooth anchor portion 620 is identical or similar to the tooth anchor portion 320. The main body portion 630 is similar to the main body portion 330. The main body portion 630 has a bore 632 formed therein with a threaded section 635. Living hinge 340 is formed therein and defined by slot 342. Urging member 375 is disposed within the bore 632 and threadingly engages the threaded section 635. Unlike the pin assembly 300, the pin 610 has no gear section.

The sleeve 700 is similar to the sleeve 400 and includes a hollow interior 710. The sleeve 700 can also include one or more features 705 that serve to locate and fix/anchor the sleeve 700 within the base 270. As discussed above, the base 270 is formed around the sleeve 700 that are fixed in place in their proper locations so that the pins attached to the dowel pins are aligned therewith. For example, the sleeve 700 includes a pair of opposing rails 705 that are formed along the outer surface of the sleeve 700. The rails 705 do not extend along the entire length of the sleeve 700. The rails 705 serve to anchor the sleeve 700 within the base.

The pin assembly 600 also includes a plug 650 that is constructed to intimately mate with the sleeve 600. The plug 650 has a post portion 652 and a base portion 654 with the post portion 652 extending outwardly from the base portion 654. The post portion 652 can be a hollow cylindrical shaped structure (e.g., a tube). The plug 650 (post portion 652) is  
5 inserted into the bore 710 of the sleeve 700. The plug 650 can be formed of any number of different materials including but not limited to polymeric materials and rubber. For example, the plug 650 can be in the form of a rubber plug (stopper) that is inserted into the bore 710 of the sleeve 700 to close off the sleeve 700. It is desirable to close off the bore 710 of the sleeve 700 during the formation of the base 270 when the base 270 is formed since it is not  
10 desirable for the material that forms the base 270 to enter the bore 710. If this material enters the bore 710 and hardens, it will obstruct the bore 710 and the operation of the pin. In use, the plug 650 can easily be removed.

The use of the present model for the formation of the plurality of aligners to cause the patient's teeth to move from the initial tooth arrangement to the final tooth arrangement is  
15 now described. More specifically, the orthodontist has a great amount of discretion in the customization of the orthodontic treatment plan for a particular patient since the orthodontist can make proposed adjustments to one or more tooth dies by manipulating the respective pin assemblies 300 to cause the desired movements of the respective tooth dies.

There is a significant cost savings using the present invention since the adjustments  
20 that are made using the assembly of the present invention can be made by conventional heat-forming technique without computer controlled machines on site. The better interaction with a patient by showing the patient corrective steps on a material 3-D model instead of a

computer screen. In other words, the personal dentist can work with his or her own patient in developing and personally illustrating the proposed treatment plan. This is a significant advantage since the patient will better appreciate the course of treatment when it is shown before their very eyes in a physical 3-D model. Planning every next step based on a real  
5 progress taking into account the actual patient's response to the adjustments, etc., as opposed to charter an entire course of treatment as is done in the prior art systems. Since the system and method of the present invention is customizable, the course of treatment can be changed mid treatment if the patient is making more or less progress than anticipated.

After moving the respective tooth dies from the initial tooth arrangement to a first  
10 tooth arrangement, the model is then used in the formation of a unique aligner. To form the aligner, the model is inserted into a vacuum forming system. The vacuum forming system has a compartment that has a platform that receives the model. Surrounding the model is a plurality of vacuum apertures or the like which cause a vacuum to be established in the compartment. The platform on which the model rests is often called a vacuum plate. The  
15 system includes a heating unit that includes a heating element. The heating unit is typically rotatable and is spaced from the platform. The vacuum forming system has a frame that includes the platform and has a hinged frame part that receives a sheet of vacuum forming material. The hinged frame part is closed and secured with a frame latch, thereby positioning the sheet of vacuum forming material over the model. The heating unit is then  
20 swung into position squarely over the sheet of vacuum forming material and at this time, the vacuum is on. The plastic vacuum forming material heats quickly and begins to soften and the vacuum forming material flows over the model (tooth dies).

A suitable vacuum forming system is commercially available from Buffalo Dental under the trade name Sta-Vac II. The Sta-Vac II uses a heating element other than a laser and therefore, unlike the Invisalign® system, vacuum forming materials of greater thickness can be used. As previously mentioned, the Invisalign® system uses a laser light vacuum forming  
5 system and therefore, a thin sheet of vacuum forming material is required to be used due to the heating properties and capabilities of the laser.

The vacuum forming system is then turned off and after a sufficient cooling period, the formed aligner is removed and can be cut to remove fringe material, etc., thereby leaving behind an aligner (polymeric shell) that is fabricated for placement over the patient's teeth.  
10 As described above, the aligner applied a resilient repositioning force against the tooth or teeth to be repositioned.

The patient's teeth are repositioned from their initial tooth arrangement to an intermediate and/or final tooth arrangement by placing a series of incremental aligners over the patient's teeth. To form the next aligner for use by the patient, the orthodontist simply  
15 manually manipulates the tooth die(s) that requires further repositioning and thereby causes adjustment of the respective pin assembly 300. Once the proper tooth arrangement is achieved, the orthodontist repeats the process and places the adjusted model into the vacuum forming system. The vacuum forming system is operated, as described above, a new aligner is formed.

20 The above process is repeated until the desired number of aligners is formed. Unlike the conventional processes, a treatment plan using the aligners of the present invention is

more customizable and the length of treatment can be reduced since the thicker aligners can be used and therefore, more aggressive incremental changes can be realized.

It will be appreciated that the pin assembly 300 according to the present invention permits the model of the patient's teeth to be interactive in that the orthodontist can  
5 manipulate individual tooth dies until the tooth die assumes a desired tooth arrangement that includes an incremental change relative to the prior tooth arrangement. The degree and magnitude of the incremental tooth change is left up to the individual orthodontist. As a result, the orthodontist can customize and tailor the treatment plan to a particular patient and not be limited by parameters, such as the thickness of the aligner due to the starting thickness  
10 of the sheet of vacuum forming material.

It will be appreciated that there are other manners of interlockingly mating the pin 310 with the sleeve 410. For example, the outer surface of the main body section 330 can include a plurality of rings that are formed of spaced bumps or projections. The spacing between the bumps represents the degree of rotation for one rotational movement of the pin 310 within the  
15 sleeve 400. In this embodiment, the bumps can form circumferential rings or they can form partial circumferential rings. The sleeve 400 is formed with complementary rings of openings, with each opening being sized to receive one bump. Thus, when the pin 310 is inserted into the sleeve bore 410, the bumps ride along the inner surface of the sleeve 400 until they are aligned with complementary openings at which time, the bumps are received  
20 into the openings, thereby lockingly coupling the two together. When controlled and precise rotation of the pin 310 relative to the sleeve 400 is desired, the tooth die and thus, the pin 310 is rotated causing the bumps to disengage one set of openings and the subsequently engage

the adjacent set of openings that all are formed in the same ring structure. This results in a controlled rotation of the pin 310 within and relative to the sleeve 400.

Now referring to Figs. 8-11 in which an alternative dowel pin assembly 800 is shown. The assembly 800 includes a pin 810 and a complementary sleeve 900. As with the earlier  
5 embodiments, a portion of the pin 810 is fixedly attached to the tooth die and another portion of the pin 810 that extends below the tooth die is for insertion into the sleeve 900 that is fixedly coupled to the base of the model.

The sleeve 900 is an elongated member that has a first end 902 and an opposing second end 904. The sleeve 900 is a hollow member and therefore includes a bore 910  
10 formed therethrough. The bore 910 is open at both the first end 902 and the second end 904. The sleeve 900 can have any number of different shapes. In the illustrated embodiment, the sleeve 900 has a hexagonal shaped outer surface; however, the bore 910 can have a different shape and in the illustrated embodiment, the bore 910 is circular shaped.

The sleeve 900 is formed so that at one end of the bore 910 a step or floor 915 is  
15 formed internally within the bore 910. The floor 915 acts as a stop in that it limits the longitudinal movement of the pin 810 since when the pin 810 seats against the floor 915, the advancement of the pin 810 in the bore 910 is complete and the pin 810 is properly located within the sleeve 900.

In accordance with the present invention, the sleeve 900 can have a locating and  
20 coupling element 920 that is formed within the bore 910. The illustrated coupling element 920 is in the form of a shaped recess 920 formed at the first end 902 of the sleeve 900 and in

communication with the bore 910. As shown in Figs. 10 and 11, the shaped recess 920 is directly open to the bore 910 and in the illustrated embodiment, the shaped recess 920 has a triangle shape. The shaped recess 920 extends radially outward from the bore 910 and has a predetermined height in that a floor 925 defines the bottom of the shaped recess 920. The  
5 shaped recess 920 is thus open along the first end 902 of the sleeve 900 and extends downwardly to the floor 925.

The bore 910 has a complementary shape as the pin 810 and as shown in the figures, the bore 910 has a tapered shape. The bore 910 tapers inwardly in the direction towards the second end 904 of the sleeve 900.

10 The sleeve 900 also includes an opening or hole 930 that is formed in the second end 904. The hole 930 communicates with the bore 910 and forms an entrance thereto. As described herein, the hole 930 permits a tool to be inserted for contacting and manipulating the pin 810. The hole 930 can have a different shape (e.g., circular) compared to the shape of the bore 910.

15 The sleeve 900 has a plurality of fingers or other extensions 940 that extend outwardly from the body of the sleeve 900 and assist in anchoring the sleeve 900 within the base of the patient's teeth model. In the illustrated embodiment, the extensions 940 are formed in an overlying relationship. The extensions 940 are defined by a series of notches 942 formed in one side of the sleeve 900. The depth of the notches 942 can vary leading to  
20 different sized extensions 940. In the illustrated embodiment, the depth of the notches 942 progressively increases in the direction from the first end 902 to the second end 904. This is

best shown in Fig. 11. The notches 942 are not in communication with the bore 910. The shaped recess 920 is located above the topmost notch 942.

The pin 810 is likewise an elongated structure that has a first end 812 and an opposing second end 814 with the first end 812 being the end that is fixedly coupled to the tooth die and the second end 814 being the end that is coupled to the sleeve 900. The pin 810 is actually formed of a number of distinct sections, namely a tooth anchor section 820 and a main body 830.

The tooth anchor section 820 represents the portion of the pin 810 that is inserted into the drill hole formed in the underside of the tooth die and therefore the tooth anchor section 820 is received within the tooth die and fixedly attached thereto. The tooth anchor section 820 can have a contoured or modified outer surface to assist in fixedly attaching the pin 810 to the tooth die. For example, the outer surface can be serrated or can have other surface modifying structures.

The tooth anchor section 820 can have any number of different shapes; however, the shape of the tooth anchor section 820 is complementary to the shape of the drill hole since the tooth anchor section 820 is received within the drill hole. In the illustrated embodiment, the tooth anchor section 820 has a cylindrical shape.

The anchor section 320 extends beyond the main body section 330 and therefore represents a post or the like. The anchor section 320 is preferably a solid structure to increase the integrity and strength of the connection between the pin 310 and the tooth die.

The main body section 830 is not a solid structure but rather the main body section 830 has a bore 832 formed therein. The main body section 830 can have any number of different shapes; however, the shape of the main body section 830 is complementary to the shape of the bore 910 formed in the sleeve 900 since at least a portion of the main body  
5 section 830 is disposed within the sleeve 900.

In accordance with the present invention, the main body section 830 has a living hinge 840 formed therein. The living hinge 840 is located proximate the end of the main body section 830 that interfaces with the tooth anchor section 820. The living hinge 840 is thus in the form of a cut or slot 842 that is formed in main body section 830. This slot 842  
10 partitions the main body section 830 into a first part 844 that is located above the slot and extends toward the tooth anchor section 820 and a second part 846 that is located below the slot. The living hinge 840 allows for relative movement between the first and second parts 844, 846.

At least a portion 835 of the bore 832 is in the form of a threaded bore. In other  
15 words, a section 835 of the bore is threaded. The section 835 is formed at one end of the bore 832 and in particular, the section 835 is formed at the end of the bore 832 that forms an entrance into the slot 842.

The main body section 830 also includes an urging member 875 that is located within the bore 832 and is designed to travel along the threaded section 835. In one embodiment,  
20 the urging member 875 is in the form of an urging screw that is located within the bore. The urging screw 875 has external threads that are complementary to the threaded section 835 and

therefore, the urging screw 875 threadingly mates with and travels along the threaded section 835.

In accordance with this embodiment, the pin 810 includes a locator 880. The locator 880 is in the form of an extension or protrusion that extends outwardly from the body of the pin 810 at the interface between the first section 844 and tooth anchor section 820. The locator 880 has a complementary shape as the recess 920. In the illustrated embodiment, the locator 880 has a triangular shape. The height of the locator 880 is about the same height of the shaped recess 920.

When the pin 810 is inserted into the sleeve 900 is inserted into the bore 910 and the end 814 seats against the floor 915, the underside of the locator 880 either seats against the floor 925 or is proximate thereto. It will be appreciated that locator 880 is designed to align the pin direction of tilt to the direction of tooth movement. The locator 880 thus provides a convenient, easy method of indicating the pivot or tilt direction of the pin and thus allow the dentist to set the sleeve 900 and pin 810 so that the tilt direction is properly aligned with the intended direction of tooth movement. The assembly 800 can thus be properly positioned to ensure that the tooth moves in the intended direction.

Now referring to Figs. 12-15, a dental alignment assembly 1000 is shown. The assembly 1000 is similar to the other assemblies described herein and in particular, the assembly 1000 includes a cast or model 1010 of the dentition, which is also called a die and represents a positive replica of the tooth or teeth. After forming the model 1010 of the patient's teeth in the initial tooth arrangement, it is often desirable and typically necessary to

separate one tooth die 1020 from the remainder of the model of the patient's mouth. Any number of conventional techniques can be used to separate one tooth die 1020 from the remainder of the model 1010 as described herein. In the illustrated embodiment, there are five tooth dies 1020.

5           In accordance with the present embodiment, each die 1020 that is to be controllably moved is fitted with a post 1100 that is designed to be intimately received within a base 1200. The post 1100 has a triangular shape defined by first and second side walls 1102, 1104 that are angled relative to one another and converge and intersect at a bottom thereof. The post 1100 also includes first and second ends walls 1106, 1108 that, while triangular in shape, are  
10       parallel to one another as shown in Fig. 12. A top surface 1109 of the post 1100 is a planar surface (e.g., rectangular shaped).

It will be appreciated that the dies 1020 that are not to be moved in accordance with the present invention can be fitted with convention pins (not shown) for insertion into complementary openings formed in the base 1200.

15           The base 1200 includes a top surface 1210 that is a planar surface (the bottom surface is likewise planar). The base 1200 has a slot 1220 formed along the planar top surface 1210. The slot 1220 has a shape that is complementary to the shape of the post 1100 and therefore, has a triangular shape defined by angled side walls and planar end walls. The post 1100 is thus designed to intimately fit within the slot 1210 such that the post 1100 and the attached  
20       die 1020 is prevented from rocking (moving forward and rearward). Initially, the post 1100

is prevented or at least substantially prevented from moving laterally (side to side) within the slot 1220.

Since the bottom surfaces of the dies 1020 are planar and the top surface of the base 1200 is planar, the dies 1020 seat flush against the top surface when the dies 1020 mate with the base 1200 and are inserted into the slots 1220. This is the case whether conventional pins  
5 or the post 1100 of the present invention is used.

In accordance with the present invention, lateral movement of the die 1020 can be provided by reducing the length of the post 1100 as by shaving one end of the post 1100, thereby reducing its length as shown in Fig. 15. The angled nature of the post (the side walls  
10 1102, 1104) is not disturbed and therefore, the post 1100 and die 1020 is still prevented from “rocking” within the slot 1220. By altering the length of the post 1100 to be less than the length of the slot 1220, lateral movement of the post 1100 is provided within the slot 1220. This permits the die 1020 to be moved laterally so as to closer position one tooth relative to another by forming and then subsequently using an aligner. Fig. 15 shows the degree of  
15 lateral movement that can be created by shaving some of the post material.

It will be appreciated that the amount of material removed from one of the end walls 1106, 1108 directly corresponds to the degree of lateral movement that is created. For example, if 2 mm (thickness) is removed from the end wall 1106, the die 1020 is provided with 2 mm of lateral travel within the slot 1220. Thus, the degree of desired movement of the  
20 tooth can be controlled by specifically reducing the length of the post 1100.

It will be appreciated that there can be more than one slot 1220 formed in the base 1200 if there are more than one die 1020 that is to be controllably moved in accordance with the alignment method of the present invention.

The above assembly thus provides an effective way to create lateral movement of the  
5 dies relative to one another while not altering the forward/rearward position.

While the invention has been described in connection with certain embodiments thereof, the invention is capable of being practiced in other forms and using other materials and structures. Accordingly, the invention is defined by the recitations in the claims appended hereto and equivalents thereof.

**WHAT IS CLAIMED IS:**

1. A dowel pin for use with a tooth die that is part of a dental model comprising:
  - a tooth anchor section that is configured to be fixedly attached to the tooth die;
  - a main body section having a bore formed therein and open at one end of the pin, the main body section having a slot that defines a living hinge formed therein that partitions the main body section into an upper pivotable portion that pivots about the hinge and a lower portion, wherein a section of the bore is threaded and the main body section includes an urging member that travels along the threaded bore section and can be driven into contact with the pivotable portion of the main body section, the bore forming an entrance into the slot that defines the living hinge to permit the urging member to be driven into contact with the pivotable portion; and
  - a locating member extending radially outward from the main body section, the locating member being shaped to indicate a pivot direction of the tooth die and therefore a direction of intended tooth movement.
2. The dowel pin of claim 1, wherein the urging member comprises a screw that has external threads that are complementary to the threaded bore section.

3. The dowel pin of claim 1, wherein the locating member is a shaped protrusion that extends radially outward from the main body section at an interface between the main body section and the tooth anchor section.

4. The dowel pin of claim 3, wherein the locating member is a triangular shaped protrusion that indicates the pivot direction by aligning a point of the triangular shaped protrusion with the pivot direction.

5. The dowel pin of claim 1, wherein the locating member is a triangular shaped protrusion that points to the pivot direction and accordingly also points to the intended direction of tooth movement.

6. A dowel pin and sleeve combination for use with a tooth die that is part of a dental model comprising:

a dowel pin including:

a tooth anchor section that is configured to be fixedly attached to the tooth die;

a main body section having a bore formed therein and open at one end of the pin, the main body section having a slot that defines a living hinge formed therein that partitions the main body section into an upper pivotable portion that pivots about the hinge and a lower portion, wherein a section of the bore is threaded and the main body section includes an urging member that travels along the threaded bore section and can be driven into contact with the pivotable portion of the main body section, the bore forming an entrance into the slot that defines the living hinge to permit the urging member to be driven into contact with the pivotable portion;

a locating member extending radially outward from the main body section, the locating member being shaped to indicate a pivot direction of the tooth die and therefore a direction of intended tooth movement; and

a sleeve for fixation in a base of the model, the sleeve having a central bore formed therein that is configured to receive the pin.

7. The combination of claim 6, wherein the urging member comprises a screw that has external threads that are complementary to the threaded bore section.

8. The combination of claim 6, wherein the locating member is a shaped protrusion that extends radially outward from the main body section at an interface between the main body section and the tooth anchor section.

9. The combination of claim 8, wherein the locating member is a triangular shaped protrusion that indicates the pivot direction by aligning a point of the triangular shaped protrusion with the pivot direction.

10. The combination of claim 6, wherein the locating member is a triangular shaped protrusion that points to the pivot direction and accordingly also points to the intended direction of tooth movement.

11. The combination of claim 6, wherein the bore of the sleeve includes a floor which defines a stop for the pin, the pin resting on the floor when the pin is fully inserted into the sleeve.

12. The combination of claim 11, wherein the bore of the sleeve and the exterior of the main body section of the pin have a complementary tapered shape.

13. The combination of claim 11, wherein an opening is formed at the end of the sleeve below the floor, the opening being axially aligned with the bore and forming an entrance into the bore, the opening having a reduced diameter compared to a diameter of the bore for permitting a tool to be inserted therethrough for contacting the pin.

14. The combination of claim 6, wherein the sleeve has a shaped recessed portion that extends outwardly from the bore of the sleeve for receiving the locating member of the pin.

15. The combination of claim 14, wherein the shaped recessed portion is defined by a floor, wherein when the pin is fully inserted into the sleeve, an underside of the locating member rests on the floor of the shaped recessed portion.

16. The combination of claim 14, wherein the shaped recessed portion has a triangular shape and is open along a top end of the sleeve.

17. The combination of claim 6, wherein the sleeve has fingers that extend radially outward therefrom along its length to assist in anchoring the sleeve in a patient's teeth mold.

18. The combination of claim 14, wherein the shape of the shaped recessed portion and the locating member only permit the pin to be inserted into the sleeve in one orientation.

19. A manually adjustable physical 3-D model that has a plurality of tooth dies, wherein at least one tooth die can be selectively adjusted to a new position to allow formation of an aligner that is intended to be worn on teeth of the patient comprising:

a first model part that is formed of a plurality of tooth dies;

a second model part complementary to the first model part and being in the form of a base that supports the tooth dies; and

a dowel pin and sleeve combination for use with the tooth die that is intended to be adjusted, the combination comprising:

a dowel pin including:

a tooth anchor section that is configured to be fixedly attached to the tooth die;

a main body section having a bore formed therein and open at one end of the pin, the main body section having a slot that defines a living hinge formed therein that partitions the main body section into an upper pivotable portion that pivots about the hinge and a lower portion, wherein a section of the bore is threaded and the main body section includes an urging member that travels along the threaded bore section and can be driven into contact with the pivotable portion of the main body section, the bore forming an entrance into the slot that defines the living hinge to permit the urging member to be driven into contact with the pivotable portion; and

a locating member extending radially outward from the main body section, the locating member being shaped to indicate a pivot direction of the tooth die and therefore a direction of intended tooth movement; and

a sleeve for fixation in a base of the model, the sleeve having a central bore formed therein that is configured to receive the pin.

20. A manually adjustable physical 3-D model that has a plurality of tooth dies, wherein at least one tooth die can be selectively adjusted to a new position to allow formation of an aligner that is intended to be worn on teeth of the patient comprising:

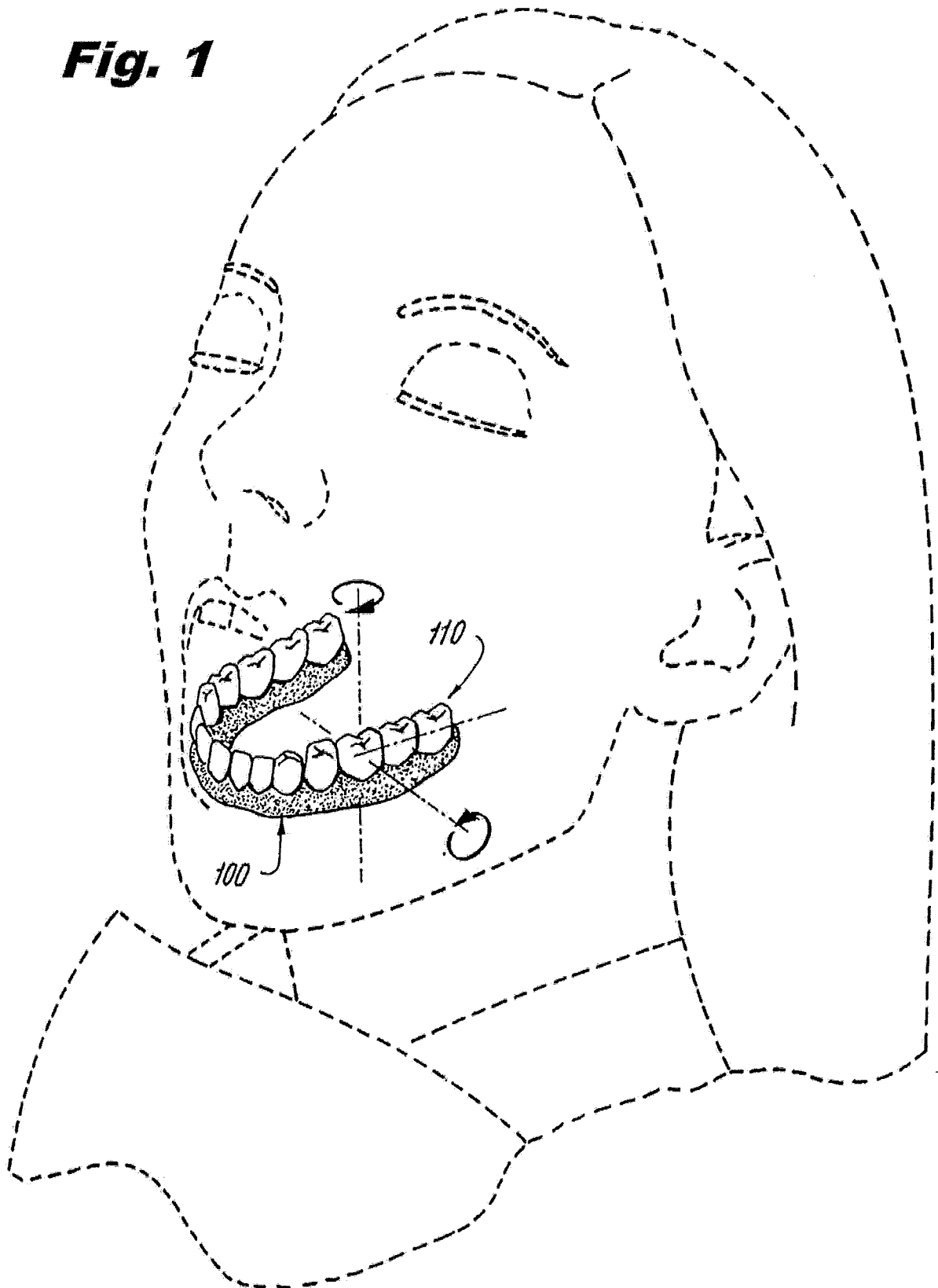
a first model part that is formed of a plurality of tooth dies;

a second model part complementary to the first model part and being in the form of a base that supports the tooth dies;

wherein at least one die includes a post extending downwardly from a bottom surface thereof, the post having a pair of angled opposing side walls and parallel opposing end walls, the base includes a slot formed in a top surface thereof, the slot having a shape that is complementary to the shape of the post so that when the post is received within the slot, forward and rearward movement of the post and attached die is prevented.

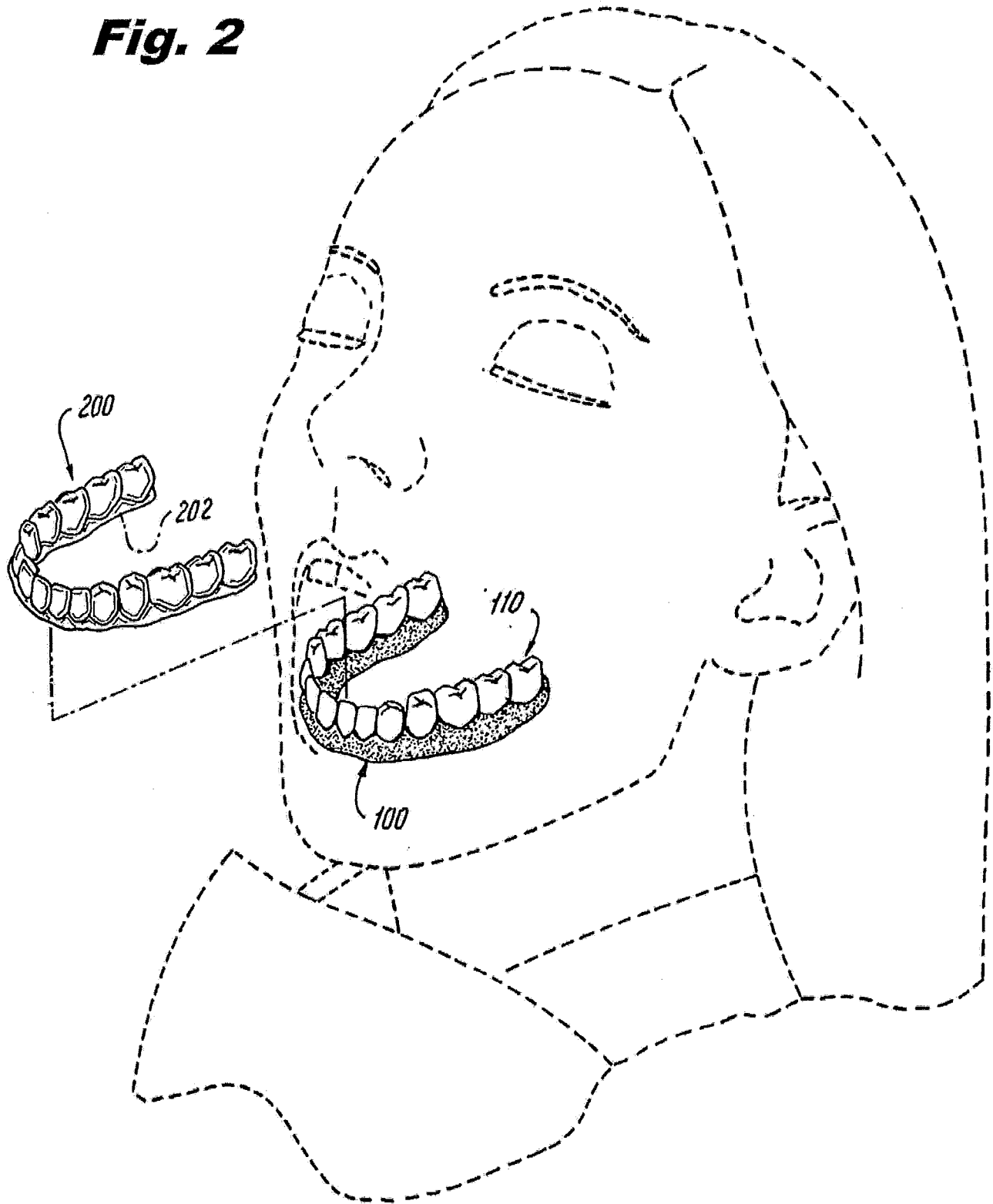
21. The model of claim 20, wherein the post has a triangular shape with the side walls converging and intersecting at a bottom edge of the post.

**Fig. 1**



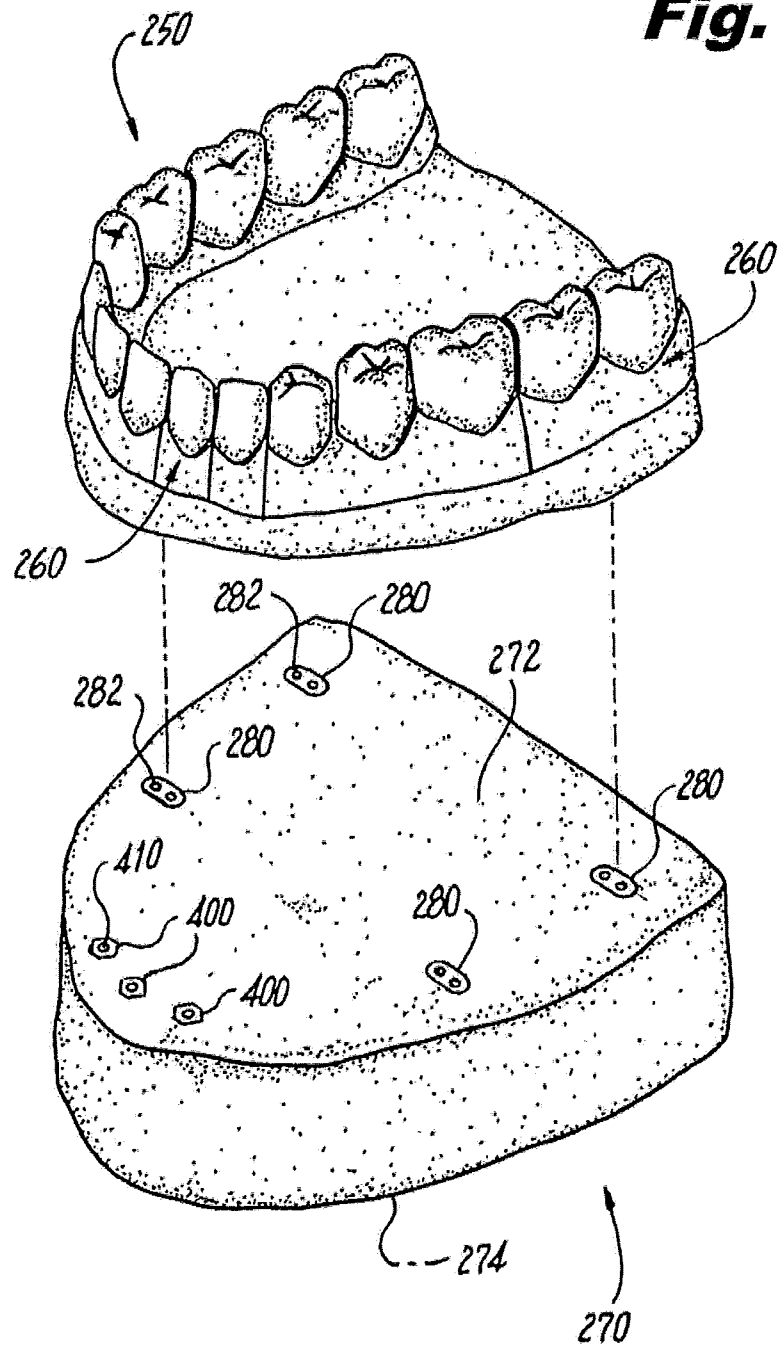
2/12

**Fig. 2**

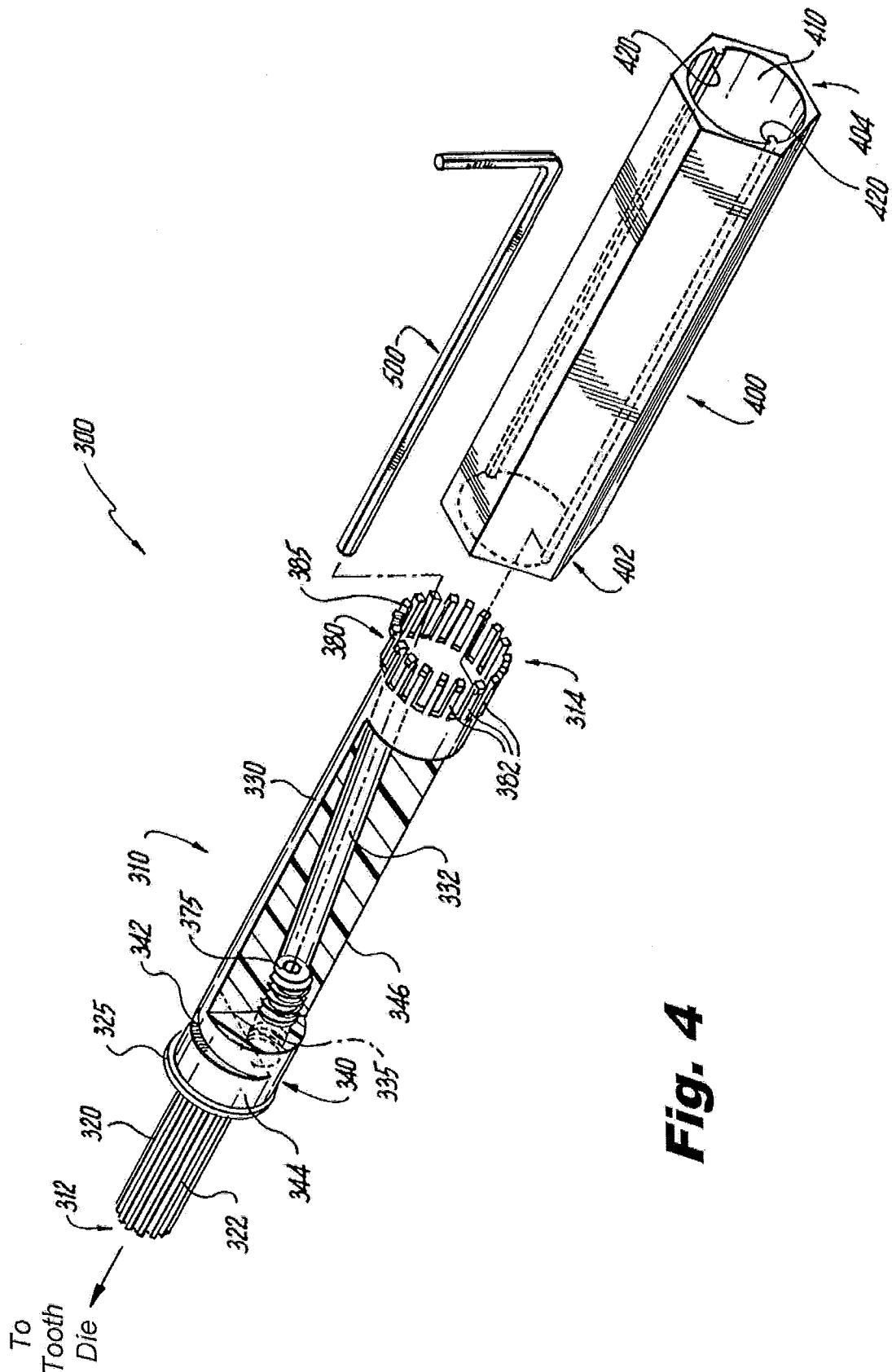


3/12

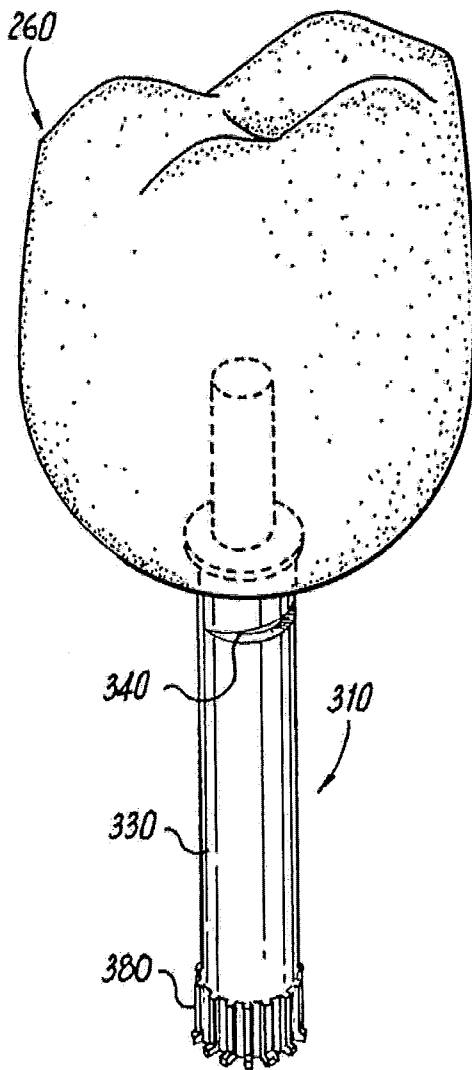
**Fig. 3**



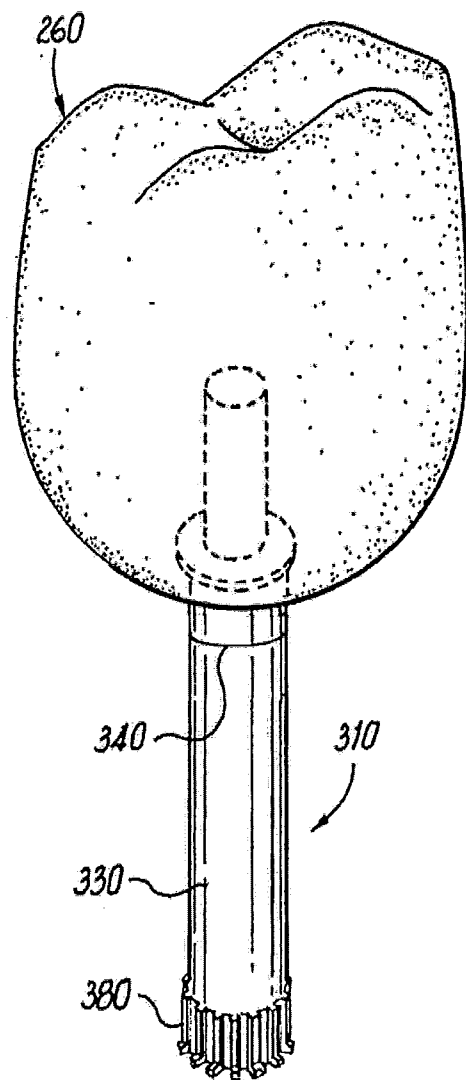
4/12



**Fig. 4**

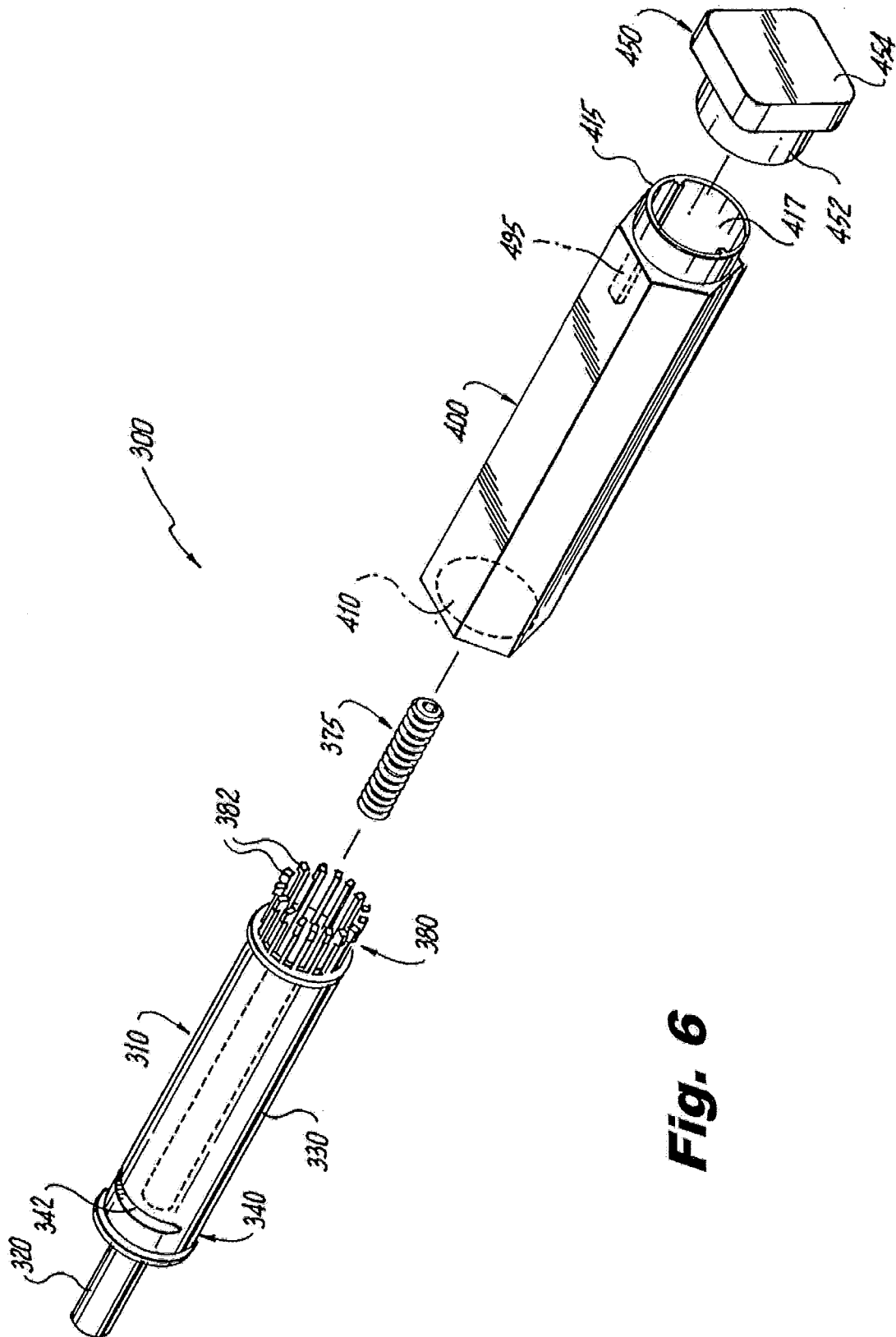


**Fig. 5A**



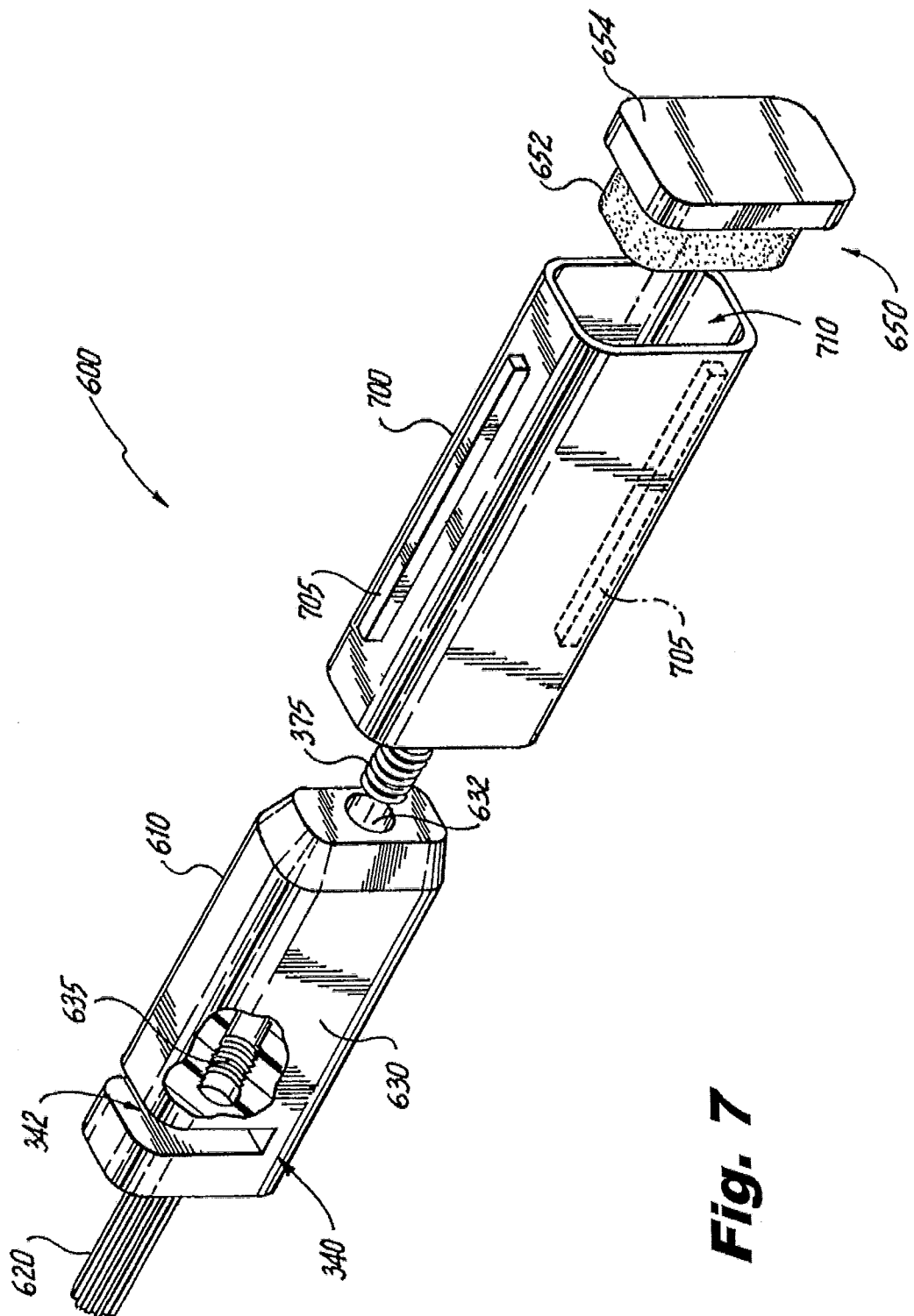
**Fig. 5B**

6/12



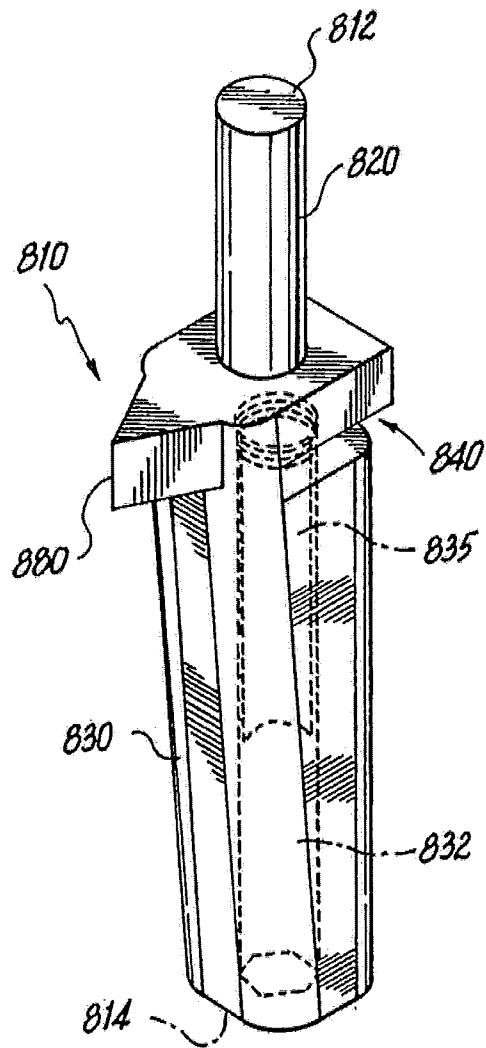
**Fig. 6**

7/12

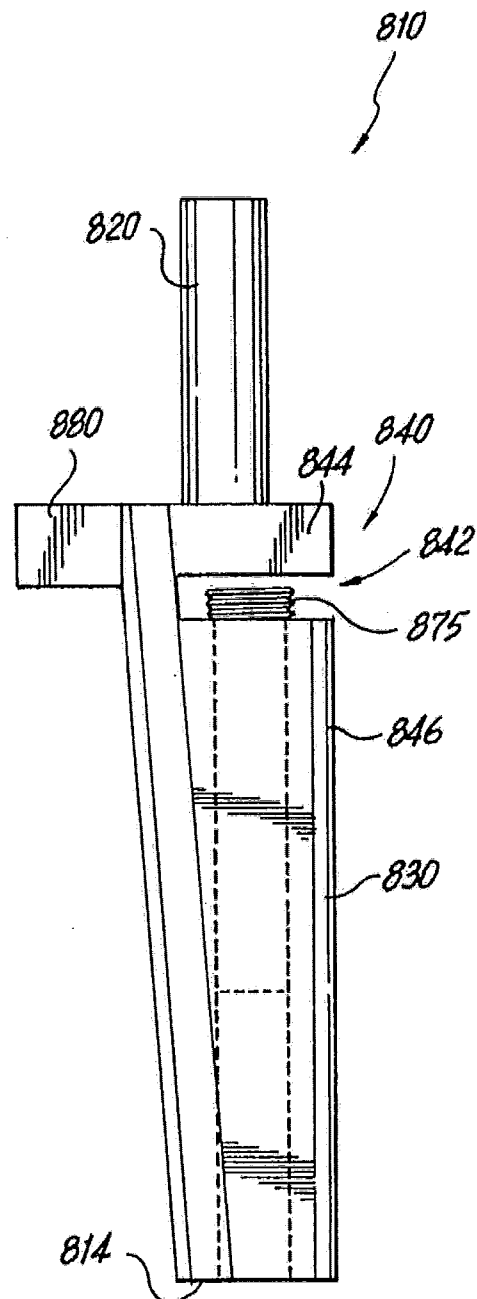


**Fig. 7**

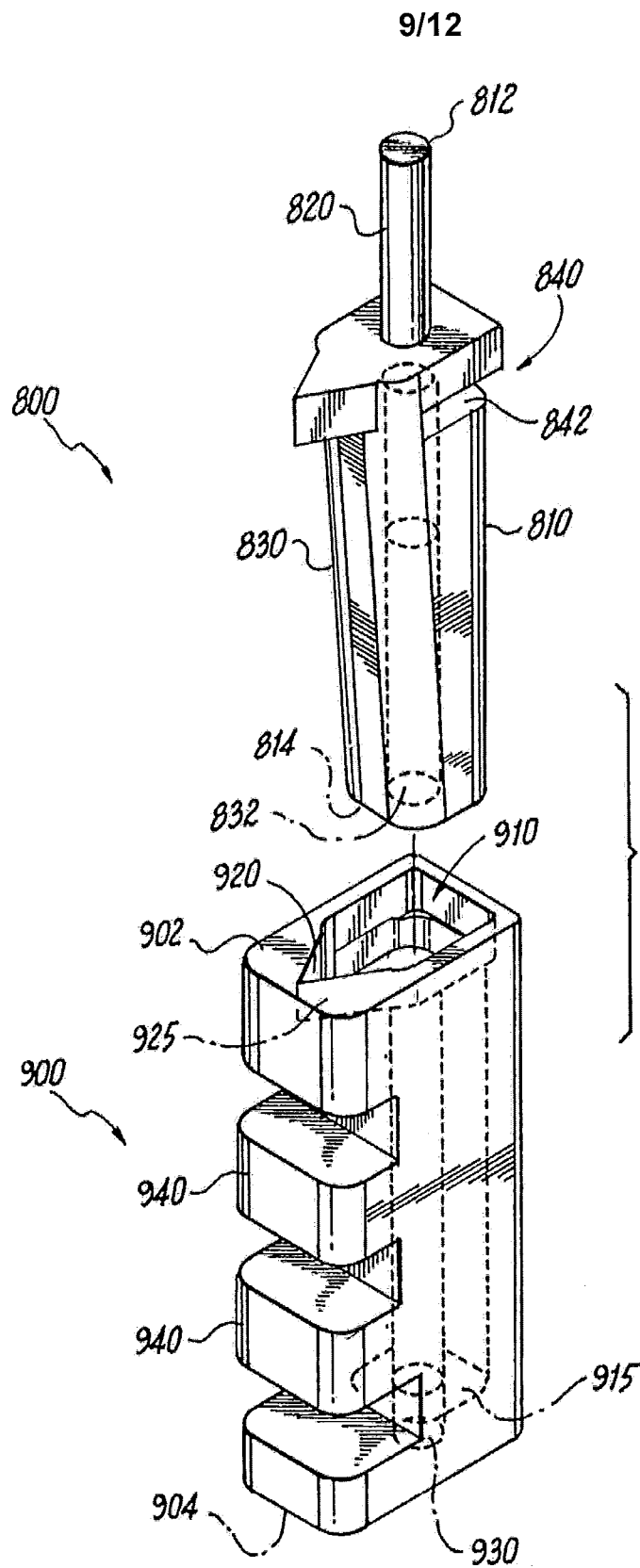
8/12



**Fig. 8**

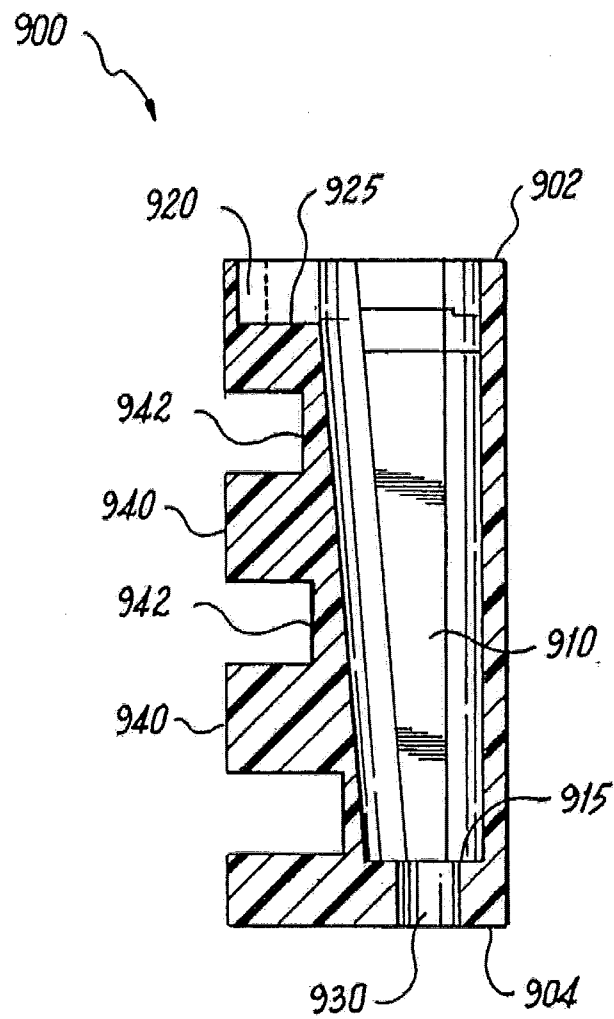


**Fig. 9**



**Fig. 10**

10/12

**Fig. 11**

11/12

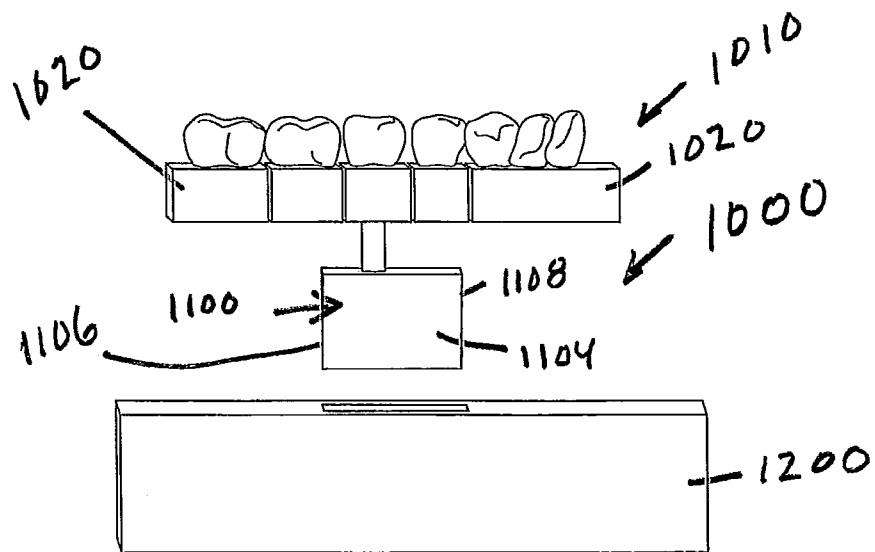


Fig. 12

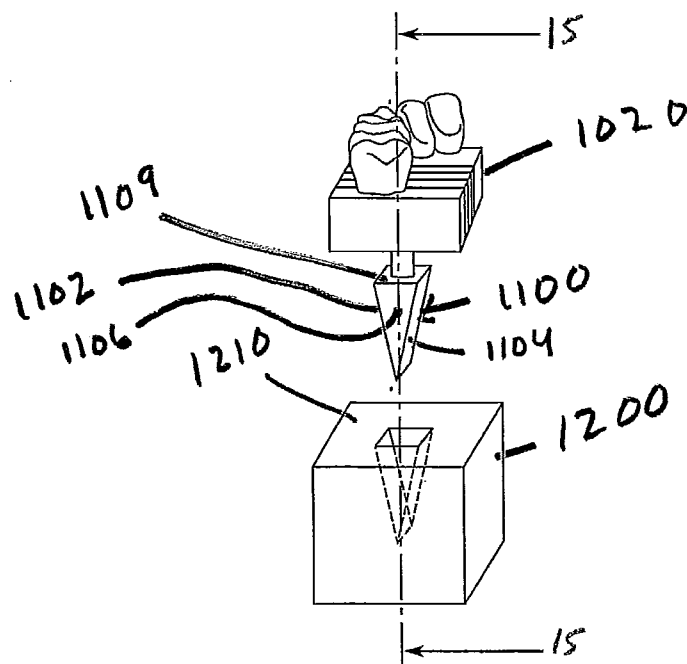


Fig. 13

12/12

