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(54) **HAMMER ASSEMBLY FOR GRAND PIANO**

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Related U.S. Application Data

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(51) **Int. Cl.**
G10C 3/18 (2006.01)

(52) **U.S. Cl.** **84/236**

(58) **Field of Classification Search** 84/13, 23, 84/26, 24, 27, 33, 66–69, 71, 173, 174, 216–221, 84/236–245

See application file for complete search history.

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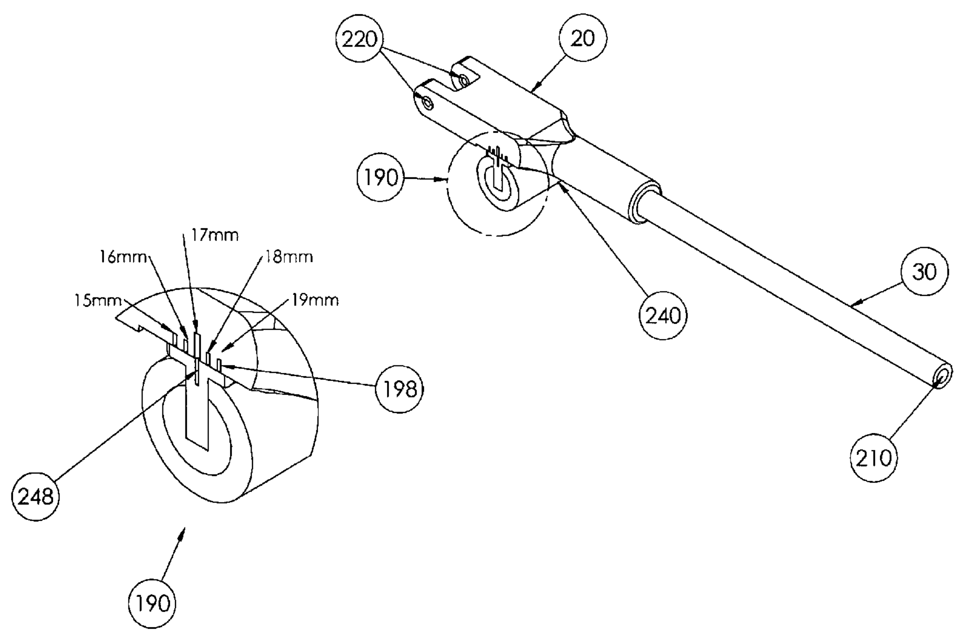
(57) **ABSTRACT**

A hammer assembly for a grand piano comprising: a hammer, a hammer shank, a tubular lever interface, and a moveable knuckle. A grand piano tubular lever interface comprises: a deep socket; a set of two hinge pin attachment holes; a void area; and a moveable knuckle visual location system. A moveable knuckle comprises: a spline; a resilient core; a synthetic buckskin wear surface, and a moveable knuckle visual location system. Novel hammer assembly allows for a direct lever relationship between hammer shank and knuckle without requirement of a forked end hammer shank with knuckle slot. Best mode spline comprises: an upright rectangular portion and a wide base portion, wherein wide base portion includes an intricate shape. Intricate shape comprises: at least one recess area and at least one protrusion area. The inverse of intricate shape is included on the bottom of the tubular lever interface. Moveable knuckle visual location system further comprises at least one pointer located on the moveable knuckle which fits snuggly into one of several notches on the tubular lever interface. Moveable knuckle can be visually located onto tubular lever interface at any one of multiple distinct locations along a range that runs parallel to the length of the hammer shank and the length of tubular lever interface. The moveable knuckle visual location system allows for custom configuration of a specifically dimensioned hammer assembly with custom "tubular lever interface center-to center" dimension to refurbish any brand of grand piano from one stock-set of hammer assembly components.

15 Claims, 9 Drawing Sheets



Prior Art

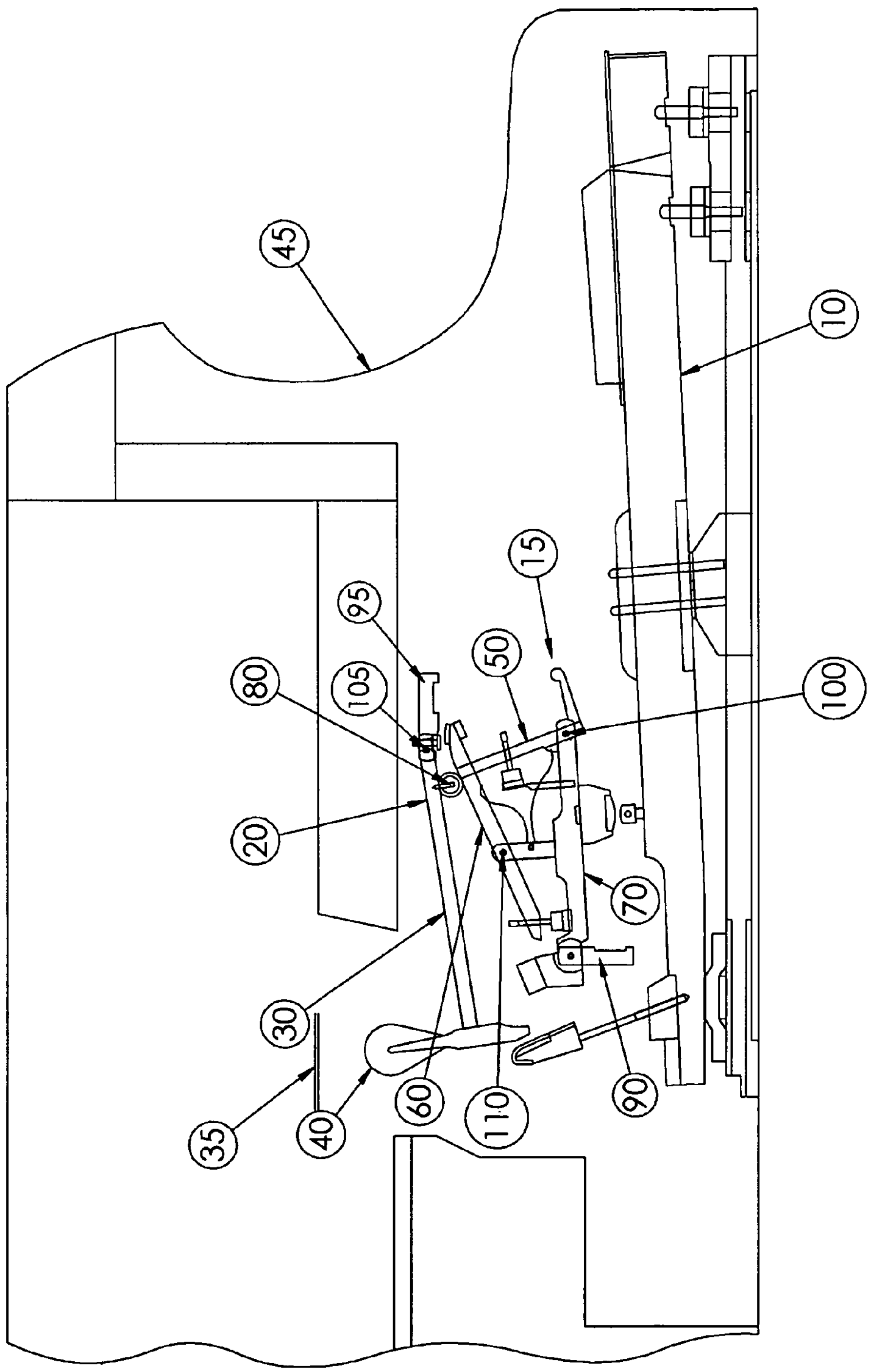


Fig. 1

Prior Art

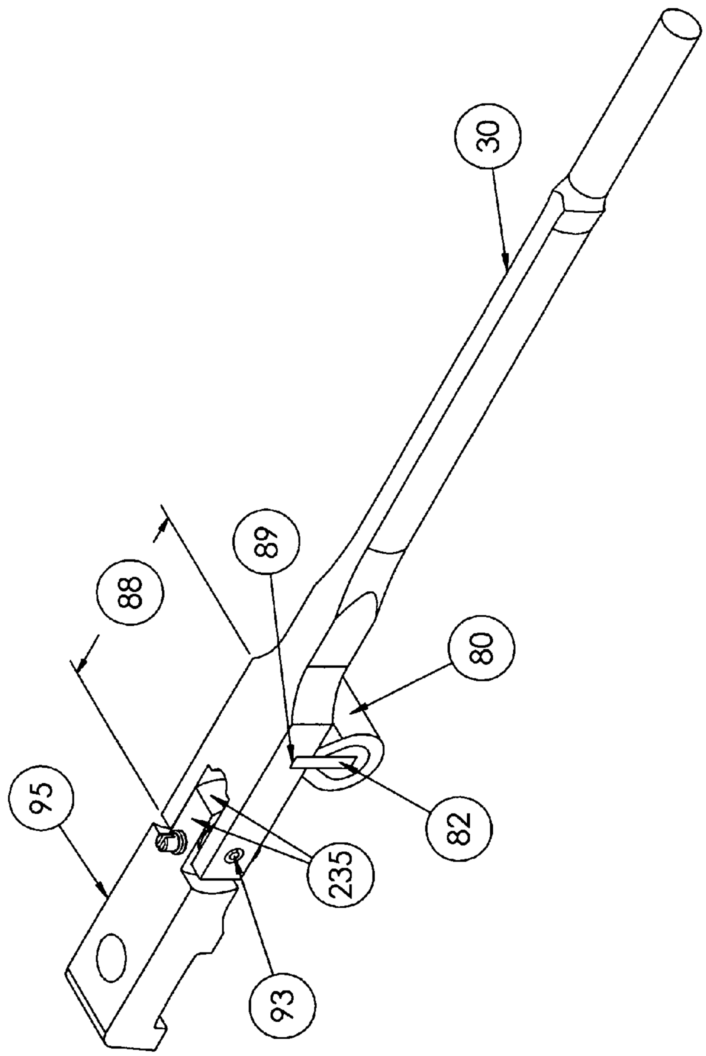
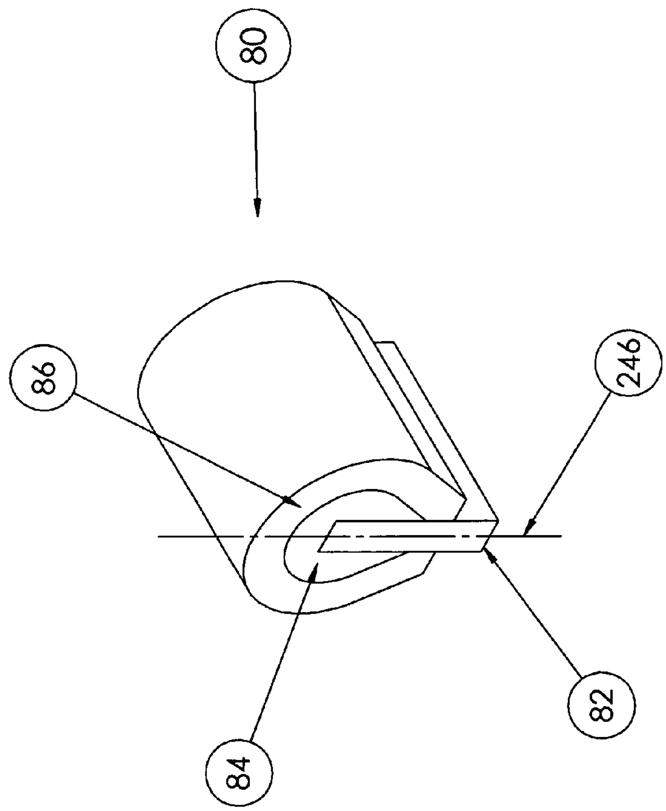


Fig. 2



Prior Art

Fig. 3

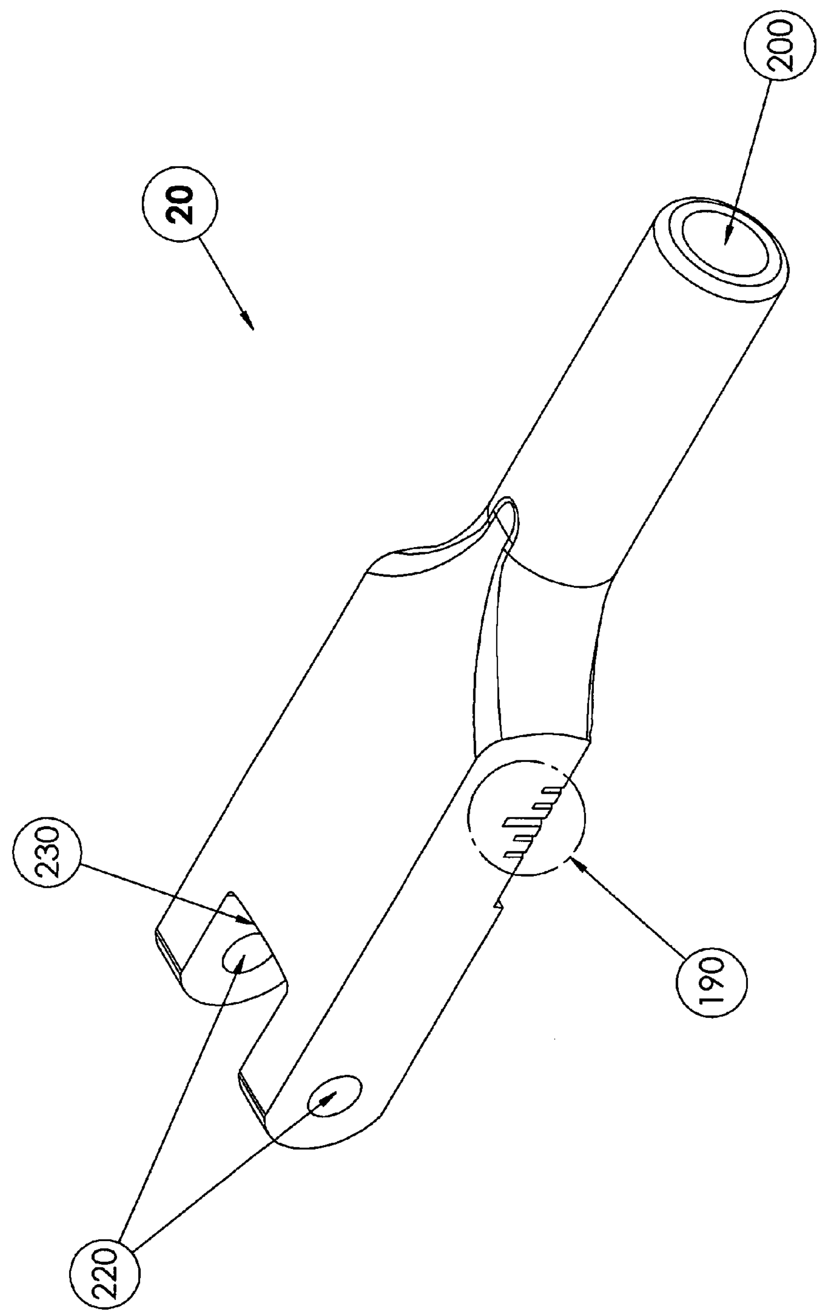


Fig. 4

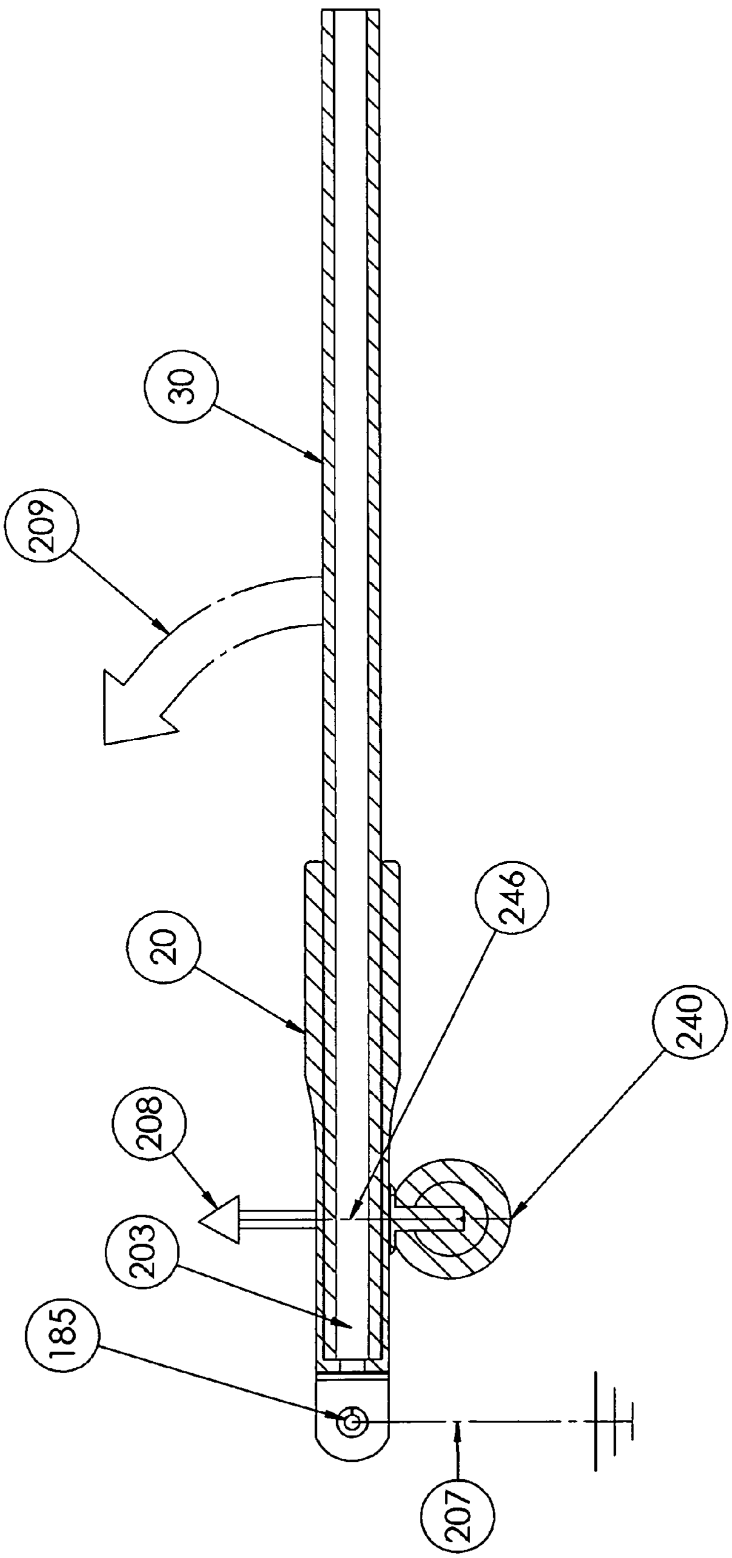


Fig. 5

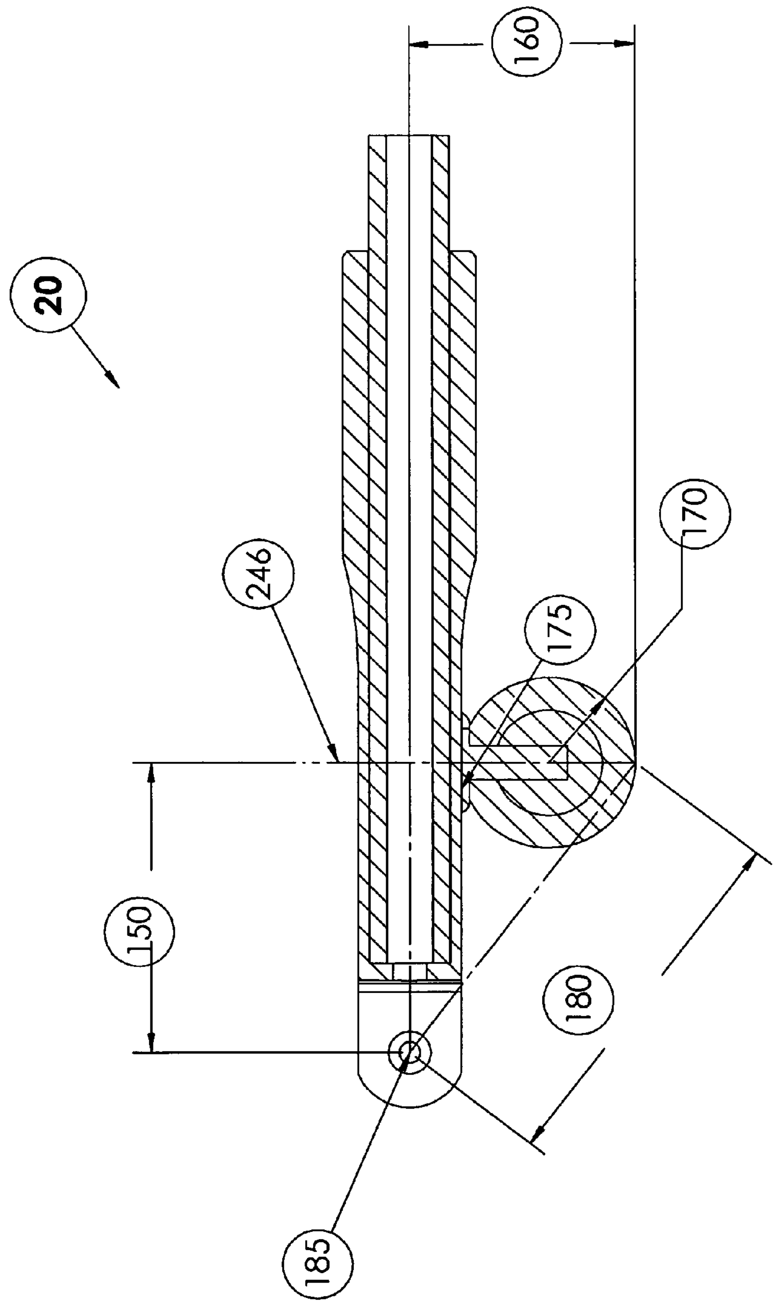


Fig. 6

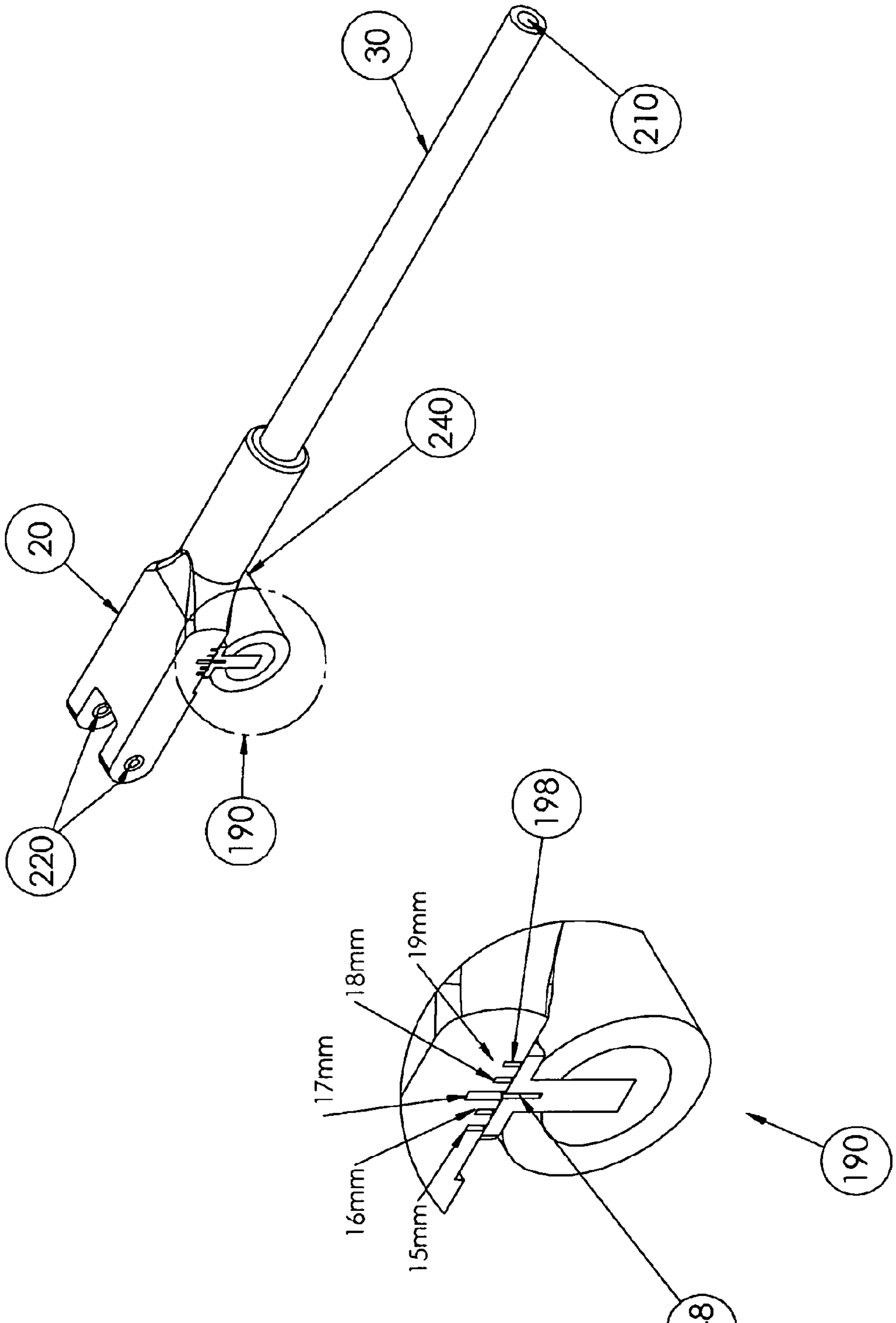


Fig. 7

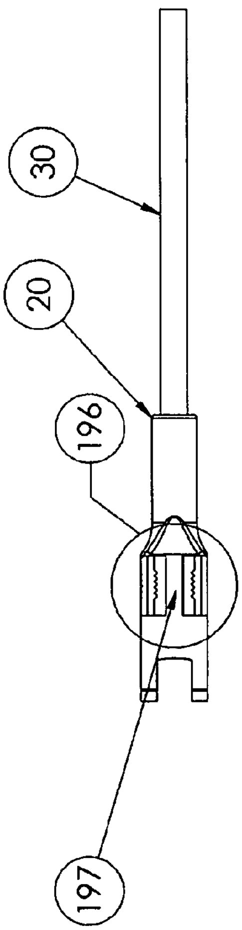


Fig. 8

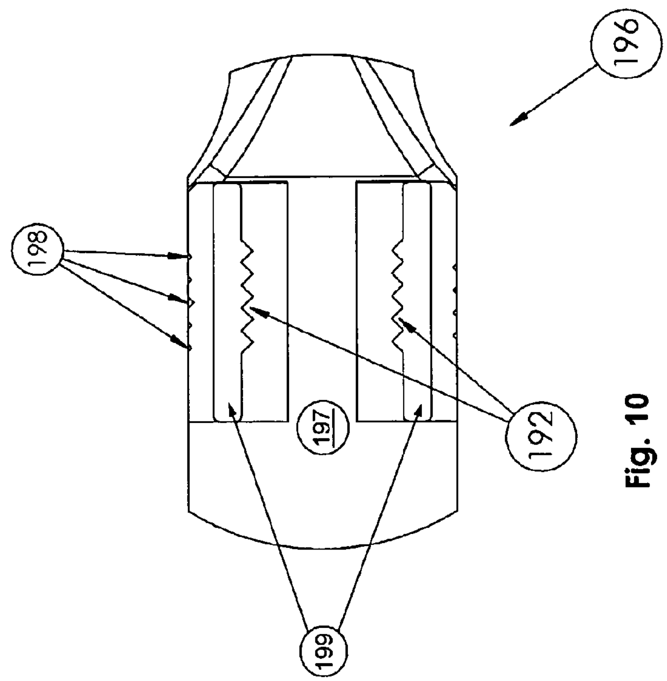


Fig. 10

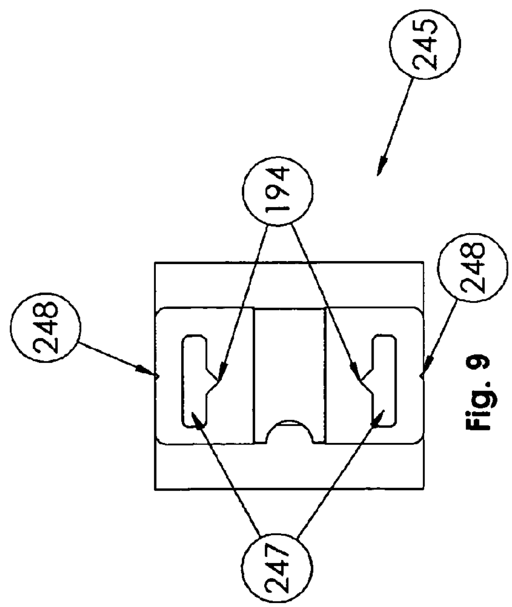


Fig. 9

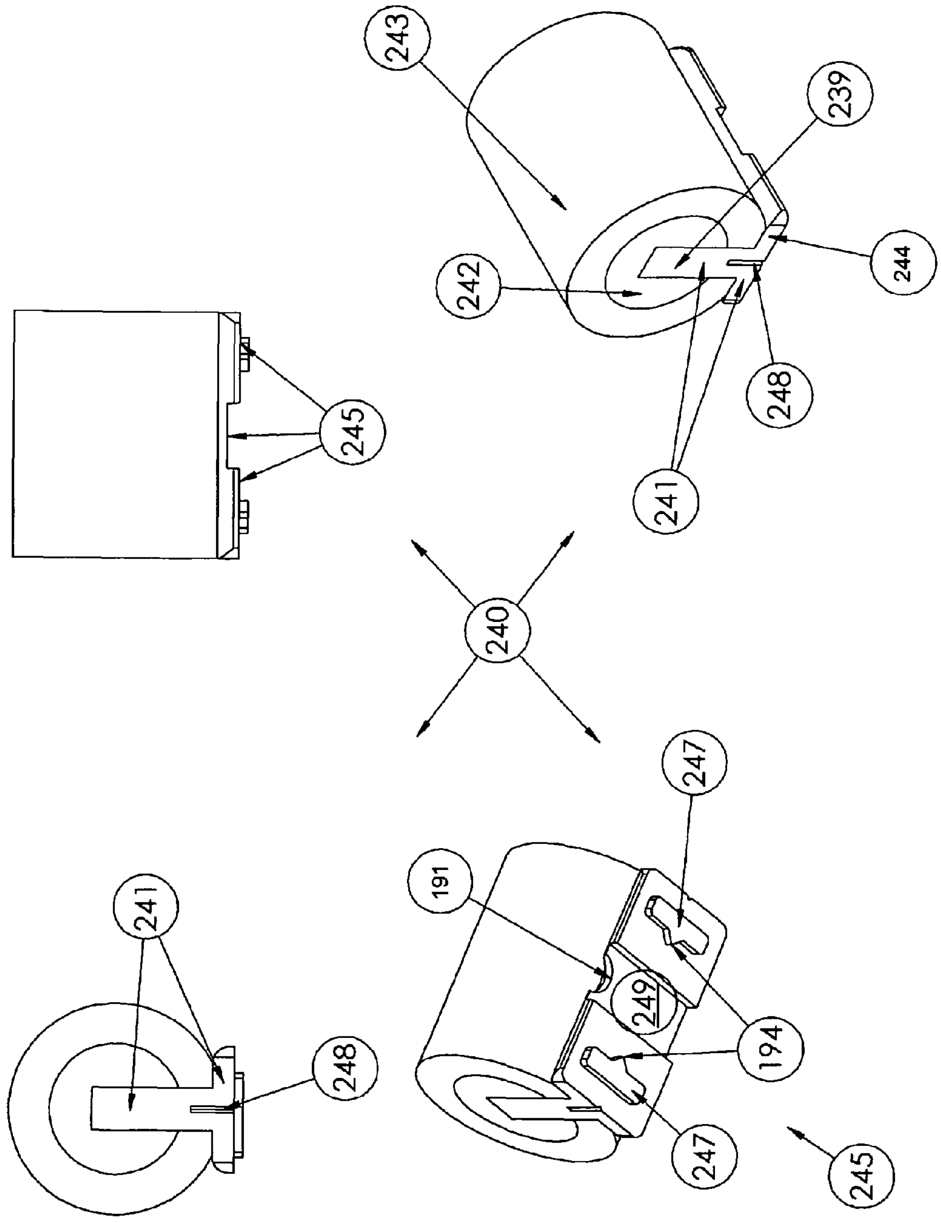


Fig. 11

HAMMER ASSEMBLY FOR GRAND PIANO

CROSS-REFERENCE TO RELATED APPLICATIONS

The instant application is a continuation-in-part of U.S. application Ser. No. 12/013,330 entitled "Hammer Shank and Shank Butt for Piano", filed on Jan. 11, 2008 now U.S. Pat. No. 7,687,692. Claim **1** pertains to matter filed with the parent application. All additional claims claim the benefit of the instant application.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

This invention relates to key operated percussion devices such as pianos and, more specifically, to the hammer assemblies of such devices. A hammer assembly according to this invention comprises: a hammer **40**; a hammer shank **30**; a tubular lever interface **20**; and a moveable knuckle **240**.

(2) Description of Prior Art

A piano produces sound as a result of a complicated mechanical chain reaction which starts with the pianist depressing a piano key which in turn actuates a piano action **15** associated with a key **10** which in turn rotates a hammer assembly associated with the piano action which in turn strikes a piano string or strings **35** to make sound.

More specifically, a depressed key **10** gives rise to motion of the damper head assembly (not shown), separating the damper head from the associated set of strings **35**, setting the strings ready to accept vibrations. The piano strings **35** are located just above the hammer. The depressed key **10** also actuates the piano action **15** thereby pushing or "throwing" the associated hammer **40** and hammer shank **30** into the associated set of strings or string **35**. The hammer **40** strikes the strings, generating a piano tone. The piano action **15** then receives or "catches" the hammer **40** and hammer shank **30** after it strikes the strings **35** and rebounds back against the action **15**. When the pianist releases the depressed key **10**, the key **10** returns to the rest position, and permits the damper head assembly to return contact with the vibrating strings **35**. The vibrations are absorbed by the damper head assembly, and the piano tone is terminated.

With a grand piano **45**, a certain amount of kinetic energy is required when depressing a key **10** in order to move a hammer **40** as imparted by the piano action **15** to the hammer shank (**20** and **30**). When a key **10** is depressed, the repetition base **70** is pushed up pivotally about the repetition flange **90**. The jack **50** is simultaneously moved upward pivotally about point **100** in the clockwise direction and pivotally about repetition flange **90** in the counterclockwise direction, resulting in a general upward motion. The jack **50** lifts the knuckle **80**, which also moves upward from double pivot motion, this time about the repetition flange **90** and point **110**. The jack **50** raises the knuckle **80** along with the hammer shank (**20** and **30**) thereby lifting the hammer **40** upwards towards the piano strings **35**. The knuckle **80** also slides along the guide surface of the balancier **60**. These both cause the hammer **40** to move upward by rotation about point **105** towards the set of horizontally stretched strings or string **35** associated with that key **10**. The hammer **40** moves with "free rotation" powered by the knuckle **80** driven by the jack **50**. The hammer shank **30** is further rotated and disconnects from the balancier **60** in order for the hammer **40** to strike the strings **35**. There is one hammer assembly and one piano action for each of the eighty-eight keys of a grand piano.

At this point, on both grand pianos and upright pianos, conventional wood hammer shanks **30** bend somewhat before whipping around to strike the strings **35**. This phenomenon can be verified by simple high speed photography of hammer motion resulting from practically every instance of piano playing. The more virtuosic the particular piano piece played, the greater the bending or deflection of the hammer shanks **30**. This is because virtuosic piano pieces require greater key depression strength with faster key depression repetitions, which results in more forceful and more frequent hammer assembly rotations. As with all deflection motion, the greater the force applied on the body, the greater the deflection.

Since the energy absorbed by a bending of hammer shank **30** does not directly translate into the production of music, it is wasted energy or energy loss of the system. Thus, more key depression energy is required in order to produce music as a result of the bending of a hammer shank **30**. Therefore, the elimination of hammer shank **30** deflection lowers the threshold energy key depression requirement for the creation of sound. Hence the elimination of hammer shank **30** deflection results in a more responsive piano that requires less effort to play.

Additionally, the weight of the hammer assembly affects the responsiveness of the piano action. The leverage of most grand piano actions is about 5-7 to one at the hammer assembly. Thus, a slight increase in the hammer assembly weight or shank weight is quickly reflected in the key down weight. I.e., an increase in weight of shank **30** results in an exponential increase in the energy requirement for key depression. Likewise, a decrease in shank weight results in an exponential decrease in key depression energy. Thus, a lighter hammer assembly results in a more responsive piano that requires less effort to play.

The grand piano hammer assembly of prior art comprises a one-piece hammer shank **30** that has a cylindrical end and a forked end **88**. The Forked end **88** attaches directly to a shank flange **95** by a hinge pin **93**. The shank flange **95** is attached to the shank rail on the piano (not depicted). Hammer shank forked end **88** needs to be wider than the shank portion because it is at this location where the knuckle **80** is attached to the member **30**. Prior art knuckles consist of a spline **82**, resilient inner core cushion **84**, and synthetic buckskin wear surface **86**. The forked end **88** of the shank **30** further comprises a slot **89** into which the knuckle spline **82** is secured, thereby connecting the knuckle **80** to the hammer shank **30** to form a sub-assembly. The forked end **88** needs to be wide at this location because the slot **89** weakens this end. Because the slot weakens the hammer shank, more deflection and bending of the shank occurs than would happen if the slot **89** were not present. As stated above, the hammer assembly must withstand deflection forces caused by the acceleration of the hammer **40** towards the string(s) **35**. The more deflection, the less efficient the hammer assembly is at accelerating the hammer **40** towards the string(s) **35**. Also, as a result of being wider, the forked end **88** is heavier, which also greatly reduces efficiency of this motion.

The hammer **40** is attached to the sub-assembly at the cylindrical end or other end of the hammer shank **30**. The cylindrical end of the shank **30** is inserted into a hole on the hammer **40**. Both knuckle and hammer attachments are typically achieved by gluing means. The shank **30** is made of wood throughout, typically hornbeam or maple wood. The prior art does not consist of separate tubular lever interface **20** and hammer shank **30** components.

Prior art hammer shanks **30** come in one standard diameter or cross sectional area that can be thinned to reduce mass. The reduced mass is particularly required in the treble section because of the need to make the hammer rebound more quickly from the string. Prior art hammer shanks **30** are thinned, in two or three increments, as the pitch of the string or strings **35** associated with the particular hammer shank increases. For manufacturing efficiency, this thinning is not continuous but rather is stepped by three separate groups—"thin", "medium", and "thick". "Thick" hammer shanks **30** are not trimmed at all and are used on the bass end of the piano. The deflection referenced above occurs in the hammer shank (**20** and **30**).

Relative to more modern materials, such as composites or plastics, wood is an inefficient raw material from which to manufacture piano action components. Wood action pieces must be drilled to produce the holes required for pivotal connections and assembly with other action components. The hole-drilling process is a laborious and costly process as compared to the production of molded piano action pieces with holes accurately formed therein during the initial molding process. Also, the production of any finished wood piece necessarily involves relatively large quantities of wasted material in the form of saw dust, which is inefficient and wasteful.

Wood is hydroscopic, i.e. wood swells, shrinks, or twists as its moisture content changes in response to the environment. This can cause binding in the action. Additionally, after repeated occurrences, this causes compression of the wood leading to failure of the piano action component thus requiring excessive in field service. For instance, wood flanges often crack due to expansion from a rise in moisture content, as the screw crushes the wood in the flange where it is fastened to the rail.

Moreover, wood has different strengths in different directions, complicating manufacturing processes, also resulting in reduced manufacturing efficiencies. Additionally, wood has inferior rigidity and strength as compared to modern composites and plastics. In particular, rigidity and strength is of the utmost importance to the hammer assembly portion of the complicated mechanical chain reaction of a piano.

Finally, the lifespan of wood piano action components is limited as compared to that of other materials such as composites or plastics because wood over time deteriorates becoming weak and unserviceable. On the other hand, composite piano action components would have several times the life span of that of their wood counterparts and thus result in more efficient manufacture and maintenance of a piano.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a new hammer assembly for a piano that requires less initial energy from the pianist's fingers in order to deliver the same sound of that generated by currently available hammer assemblies. This can be accomplished by the elimination or substantial reduction of hammer assembly deflection, without increasing the weight of the hammer assembly. Thus, it is an object of this invention to yield an improved hammer assembly with substantially increased stiffness or rigidity without additional mass, thereby effectively providing a more responsive keyboard that requires less effort to play.

It is also an object to provide a hammer assembly that can be retrofitted into any existing piano. This object includes the ability to retrofit or refurbish existing grand pianos from any manufacturer, such as Mason & Hamlin, Steinway, Yamaha, Kawai, and many others, from only one stock-set of hammer assembly components held by the piano technician. Typically, each brand of grand piano requires a unique set of hammer assemblies with specific dimensions and thus parts for one piano would not normally interchange with another. This invention allows one set of parts to be configured so as to fit into the vast majority of grand pianos. These can be provided either as pre-configured stock sets or the technician can create a custom configuration that will work for his own situation. To this end, a number of flanges and knuckle sizes are provided.

Additionally, it is an object of this invention to yield a hammer assembly with the collateral benefits of increased efficiency of manufacture and maintenance over those of their corresponding wood counterparts. Thus, it is an object of this invention to yield a more rigid hammer assembly without additional mass with the additional benefits of increased efficiency of manufacture and maintenance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross sectional view of a generic grand piano.

FIG. **2** is a perspective view of a prior art grand piano hammer shank, with attached prior art knuckle, that is assembled to a shank flange by a hinge pin.

FIG. **3** is a perspective view of a prior art knuckle for grand piano.

FIG. **4** is a perspective view of a tubular lever interface.

FIG. **5** is a cross sectional view of a tubular lever interface with attached moveable knuckle and attached hammer shank demonstrating "a lever" assembly.

FIG. **6** is a cross sectional view of the "lever arrangement" depicting critical dimensions required for proper refurbishment of existing pianos.

FIG. **7** is a perspective view of a tubular lever interface with attached moveable knuckle and hammer shank including blow-up view of moveable knuckle visual location system.

FIG. **8** is a bottom view of a tubular lever interface with attached hammer shank.

FIG. **9** is a blow-up view of intricate shape on bottom of moveable knuckle.

FIG. **10** is a blow-up view of intricate shape on bottom of tubular lever interface.

FIG. **11** depicts several views of a moveable knuckle. Top left is a side view. Top right is a front view. Bottom left is a perspective view of moveable knuckle from bottom angle. Bottom right is a perspective view of moveable knuckle from top angle.

All drawings in this application are in landscape orientation.

DEFINITION LIST

Term	Definition
10	Piano Key for Grand Piano
15	Piano Action for Grand Piano
20	Tubular Lever Interface (TLI) for Grand Piano
30	Hammer Shank
35	Piano Strings
40	Hammer
45	Grand Piano
50	Grand Piano Jack
60	Grand Piano Balancier
70	Grand Piano Repetition Base (Prior Art)
80	Grand Piano Knuckle (Prior Art)
82	Wood Spline on Knuckle
84	Resilient Core Cushion of Knuckle
86	Synthetic Buckskin Wear Surface of Knuckle
88	Fork End of Prior Art Shank Flange
89	Knuckle Slot on Prior Art Hammer Shank

-continued

Term	Definition
90	Grand Piano Repetition Flange
93	Shank Flange Hinge Pin
95	Grand Piano Shank Flange
100	Grand Piano Jack Pivot Point
105	Grand Piano Hammer Center of Rotation/Pivot Point
110	Grand Piano Balancier Pivot Point
150	Tubular Lever Interface Center-to-Center Distance
160	Tubular Lever Interface Knuckle Protrusion
170	Knuckle Diameter
175	No knuckle slot here to weaken shank assembly
180	Tubular Lever Interface Lower Lever Arm
185	Hammer Shank Center of Rotation
190	Moveable Knuckle Visual Location System
191	Half round shape
192	Notches on TLI to Locate Moveable Knuckle on TLI
194	Pointers on Moveable Knuckle to Locate It on TLI
196	Intricate Shape on Bottom of TLI
197	Protrusion area on 196
198	Graduation Marks on Side of Tubular Lever Interface
199	Recess area on 196
200	Deep Socket on TBI for Connection to Hammer Shank
203	Socket 200 extends beyond Moveable Knuckle location on TLI
207	Anchor Force from Shank Flange Hinge Pin
208	Upward Force from Piano Action
209	Rotational Motion of Hammer Assembly
210	Hollow Center of Best Mode Hammer Shank
220	Hinge Pin Holes on Tubular Lever Interface
230	Void Area on Tubular Lever Interface
235	Hinge Section of Shank Flange
239	Upright Rectangular Member of Spline
240	Moveable Knuckle
241	Spline of Moveable Knuckle
242	Resilient Cylindrical Core Cushion of Moveable Knuckle
243	Synthetic Buckskin Wear Surface of Moveable Knuckle
244	Wide Base Member of Spline
245	Intricate Shape on Bottom of Moveable Knuckle
246	Knuckle Center-Line
247	Protrusion area on 245
248	Location Mark on Side of Moveable Knuckle
249	Recess area on 245

DETAILED DESCRIPTION

A hammer assembly of this invention comprises: a hammer **40**; a hammer shank **30**; a tubular lever interface **20**; and a moveable knuckle **240**. This invention includes novel hammer shanks **30**, novel tubular lever interfaces **20**, and novel moveable knuckles **240**, where an assembly of such can be attached to prior art hammers **40** which are typically made of hornbeam wood and felt. The hammer assemblies of this invention can be installed into any grand piano of any brand.

All hammer shanks **30** of this invention are essentially cylindrically shaped made from composite or plastic material with an overall outer diameter range of 1-8 mm. Such hammer shanks **30** can be manufactured with less weight and more rigidity than their wood counterparts. This is particularly so when the hammer shank **30** is made of hollow form because hollow parts naturally weigh less than non-hollow parts. Thus, best mode hammer shank **30** of this invention is hollow in the center as depicted at **210**. The hollow cross section of the shank **30** does not have to be round, but typically is so. Likewise, the outer cross section of the shank **30** does not have to be round, but typically is so.

Hollow hammer shanks are typically most efficiently produced by an extrusion or pultrusion process. The shape of shanks **30**, which is essentially cylindrical with a constant cross-section, lends itself to efficient manufacture by extrusion or pultrusion as opposed to molding. The "one stock set" object of the invention also lends itself to the use of extrusions and pultrusions because these articles of manufacture can be

sourced in lengths longer than that of a typical hammer shank length. Typically, pultrusion articles have higher rigidity than extruded articles because the fibers used with pultrusion are continuous and typically thicker and stronger. Thus, pultrusion hammer shanks **30** are the best mode. Standard lengths can be cut to the specific length required for the particular brand of piano being refurbished and assembled to the rest of the hammer assembly.

The rigidity of plastic articles can be increased with filler additives. There are many filler additives such as glass fiber, carbon fiber, ceramics, or Kevlar fiber, respectively from least to most costly. In the case of pultruded parts, carbon fillers are considered best mode because: a) carbon fibers tend to tear apart less as compared to glass fibers and b) are less costly than ceramics and Kevlar fibers. Carbon fiber pultrusion hammer shanks **30** have the required rigidity to withstand virtuosic piano playing with minimal bending, where such ratios between rigidity and weight could not be attained by molded articles, which would be more costly to produce anyway.

More than one diameter hammer shank **30** is used in a typical piano. Thus, the invention includes separately designed tubular lever interfaces **20**, each with an appropriated sized deep socket **200**, to accept the various hammer shank **30** diameters in the public domain and those incorporated in this invention. Diameters have been chosen that provide the best balance between stiffness and mass.

A grand piano tubular lever interface **20** comprises: a deep socket **200**; a set of two hinge pin attachment holes **220**; a void area **230**; and a moveable knuckle visual location system **190**. See FIG. **4**. A tubular lever interface **20** is attached to a shank flange **95** with a shank flange hinge pin **93**. The hinge pin **93** has length that is essentially the same as the widest portion of the tubular lever interface **20**. To connect these members, the hinge pin **93** is inserted through both attachment holes **220** and the pin hole on the flange, thereby creating a pivotal connect between these members, thereby creating "a hinge" arrangement between said members. Void area **230** is necessary to allow clearance during rotation of tubular lever interface **20** around shank flange **95**. Thus, **230** is the female section of first hinge member **20**, while **235** is the male section of second hinge member **95** to form said hinge arrangement.

A grand piano tubular lever interface **20** is attached to one end of the hammer shank **30** at deep socket portion **200** of tubular lever interface **20**. After the shank section **30** has been cut to size, it is affixed into deep socket **200** typically by glue or other similar means of connection, thereby forming a subassembly. The moveable knuckle **240** is then attached to the tubular lever interface **20** at the proper location using a moveable knuckle visual location system **190**. Further, a grand piano hammer **40** is connected to the other end of said hammer shank **30** with glue or other similar means, thereby forming said hammer assembly. Normal woodworking glues can be used to attach the hammer in place by roughing the gluing surface of the shank before gluing.

The moveable knuckle **240** transmits energy from the upward moving jack **50** to the tubular lever interface **20** and the hammer shank **30**. As the jack **50** moves upwards as the result of a keystroke, the moveable knuckle **240** also moves upwards, thereby pushing the tubular lever interface **20** upwards, which in turn pushes the hammer shank **30** upwards. The leverage applied to the hammer assembly of a grand piano may be adjusted according to certain criteria of the tubular lever interface **20**. These criteria are tubular lever interface center-to-center **150**, tubular lever interface protrusion **160**, knuckle diameter **170**, and tubular lever interface lower lever arm **180**. See FIG. **6**. Criteria **150** is defined as the distance between the hammer shank center-of-rotation **185** (which is same location of **105**) and the knuckle center-line **246**. Knuckle center-line **246** is defined as the center-line of the member, as viewed from the side. See FIG. **3**. Tubular lever interface protrusion **160** is varied by adjusting the knuckle diameter **170**. Together, these two criteria determine the tubular lever interface lower lever arm **180**. A particular brand of grand piano likely requires these criteria be specific and different from those of other brands of grand piano. Typically, different brands require a specific tubular lever interface center-to center dimension **150** and a specific tubular lever interface protrusion dimension **160**.

A moveable knuckle **240** comprises: a spline **241**; a resilient cylindrical core **242**; a synthetic buckskin wear surface **243**, and a moveable knuckle visual location system **190**. The spline **241**, the cylindrical core **242**, and the synthetic buckskin wear surface **243** must be sized for each desired protrusion dimension. For a given piano one need only select the proper option. Thus, it may be required to stock more than one size moveable knuckle **240** to fulfill the full range of the retrofitablity object. Said moveable knuckle visual location system **190** can be incorporated into the spline member **241**, where both are a part of an integral member. Best mode spline **241** comprises: an upright rectangular portion **239** and a wide base portion **244**. Resilient cylindrical core **242** and wear surface **243** are affixed primarily to upright rectangular portion **239**. Wide base portion **244** includes an intricate shape **245** on its bottom surface. Intricate shape **245** comprises: at least one recess area **249** and at least one protrusion area **247**. The inverse of intricate shape **245** is included on the bottom of the tubular lever interface **20** at **196**. Thus, inverse intricate shape **196** comprises: at least one protrusion area **197** (to match the recess **249** on the moveable knuckle) and at least one recess **199** (to match the protrusion **247** on the moveable knuckle). These alternate inverse shapes fit snugly together when pressed together and have proper clearance between shapes for glue or similar connection means. The "alternate inverse shape" design yields surfaces that are very conducive to affixing to each other by glue or similar connection means to yield a strong and rigid permanent connection. Despite both **196** and **245** being labeled as "bottom" surfaces, it is these "bottom" surfaces which marry together to yield a subassembly. As oriented in an assembled piano action **15**, the bottom of moveable knuckle is actually located on top of the knuckle.

Moveable knuckle visual location system **190** further eliminates the need for the knuckle slot **89** on the hammer assembly which in turn allows for a weight reduction in the hammer assembly. There is no knuckle slot at **175**. As stated above, knuckle slot **89** significantly reduces the strength of and adds weight to the hammer assembly. With the moveable knuckle location system of this invention, no slot **89** is required, thus hammer assembly components may be made lighter and more rigid.

Additionally, this design allows for deep socket **200** to exist in tubular lever interface **20**. If slot **89** were required, it would interfere with deep socket **200** and hammer shank **30**, requiring a gap in these members, which would significantly reduce their rigidity to the point of failure. Thus, both slot **89** and deep socket **200** could not be present at the same time. Deep socket **200** is advantageous for two reasons. First, the deep socket **200** essentially yields a hollow tubular lever interface **20** which in turn yields a lighter hammer assembly. Secondly, deep socket **200** provides a strong lever arrangement between the knuckle **240** and the shank **30**. See FIG. **5**. Without **200**, during the course of a piano action cycle, knuckle **240** would push upwards on the tubular lever interface **20**. This force, thus, requires that member **20** be strong and rigid to resist deflection, which in turn requires additional weight of member **20**. Whereas shank member **30**, being a hollow pultrusion of composite carbon fiber material, as stated above, is better equipped to handle such upward force without deflection at a better "per weight" basis than member **20** which is a molded article from practical and efficient means. With deep socket **200**, shank **30** can be inserted all the way into tubular lever interface **20**, beyond knuckle center-line at **246**, allowing direct force transfer from knuckle **240** to shank **30**, creating a lever relationship between said members. Such lever arrangement results from upward force **208** (from piano action) upon hammer assembly which is secured by fulcrum **185**, at hammer shank center of rotation **105**, where hammer assembly is anchored steady to hinge pin by force **207**, thus creating the lever arrangement, which results in hammer assembly motion **209**, with limited deflection. Thus, moveable knuckle visual location system **190** allows for a more rigid, lighter hammer assembly, thereby improving piano action response.

The moveable knuckle visual location system **190** further allows for custom configuration of a specifically dimensioned hammer assembly to fit any brand of grand piano. Intricate shape **245** further comprises at least one pointer **194**, preferably 2, which snuggly fits into one of several notches **192** within intricate shape **196**. Pointers **194** are located on the bottom of moveable knuckle **240**. Notches **192** are located on the bottom of tubular lever interface **20**. Moveable knuckle **240** can be located onto tubular lever interface **20** at any one of multiple distinct locations along a range that runs parallel to the length of the hammer shank **30** and the length of tubular lever interface **20**. Thus, a moveable knuckle **240** can be affixed to a tubular lever interface **20** at the specific location to yield the exact tubular lever interface center-to-center dimension **150** required by a particular brand of grand piano to allow for proper piano action function.

The moveable knuckle visual location system **190** further comprises a visual scale to allow a piano technician to quickly attach a moveable knuckle **240** to a tubular lever interface **20** at the required location. This is accomplished by a location mark **248** on each side of moveable knuckle **240** and graduation marks **198** located on each side of a tubular lever interface **20**. Location marks **248** are located on the moveable knuckle center-line **246**.

Taking into account that most grand piano actions **15** require a tubular lever interface center-to-center dimension **150** of 15-19 millimeters, the moveable knuckle visual location system **190** is designed to designate an attachment location within this range. Thus, there are a sufficient number of notches **192** that span a range of at least 4 mm along the length of the tubular lever interface **20**. In the best mode, notches **192** are sized approximately 1.0 mm in width and pointer **194** is also sized at approximately 1.0 mm in width. The pointer and notches are sized so that the pointer snugly fits inside of a notch, thus the pointer may be slightly less than 1 mm wide and the notches may be slightly more that 1 mm wide.

Marks **248** and **198** are "positionally" related to notches **192** and pointers **194** on a continuous basis, i.e. the distance between a mark **248** and pointer **194** is constant and the distance between marks **198** and their corresponding notches **192** is constant, as measured in one dimension along the long axis of the hammer assembly. Thus, when members **20** and **30** are attached to yield a tubular lever interface center-to-center dimension **150** of 17 mm, for instance, the visual moveable knuckle visual location system **190** correspondingly designates 17 mm. See FIG. **7**. The best mode allows for 9 distinct positions from 15-19 with 0.5 mm increments. Therefore, a hammer assembly can easily be assembled with the required center-to-center dimension **150** to yield proper functioning of the piano action in a relatively short time period.

In the best mode, pointer **194** is off-set from center line **246** by 0.25 mm. This allows 0.5 mm increments by rotating the knuckle 180 degrees in relation to the tubular lever interface **20**. For instance, starting at the 17 mm position, the location marks **248** align with the center graduation mark **198**. To relocate moveable knuckle **240** to the 17.5 mm position, the knuckle **240** is rotated 180 degrees and re-attached to tubular lever interface **20** with reversed pointers **194** nesting in the same notches **192** as before in the 17 mm position. To then relocate to the 18 mm position, the knuckle **240** is again rotated and attached to the tubular lever interface **20** with pointers **194** nesting in the adjacent set of notches (toward the hammer) to those used in the 17 mm position. To allow the technician to know which way the knuckle should be rotated, there is a half round shape **191** positioned on one edge of the knuckle spline **241**. When the half round **191** is pointed away from the center-of-rotation, knuckle positioning occurs on integer-millimeter designations and vice versa for half-millimeter designations. In this fashion, moveable knuckle **240** may be positioned at 15, 15.5, 16, 16.5, 17, 17.5, 18, 18.5, and 19 mm tubular lever interface center-to-center distances **150** while notches and pointers are 1 mm in width.

Best mode tubular lever interfaces **20** are made of composite material or plastic material. Composite is defined as an engineered material made from two or more constituent materials with significantly different physical or chemical properties and which remain separate and distinct on a macroscopic level within the finished structure. Composites and plastics yield advantages over wood, relating to efficiency of manufacture and maintenance, as discussed in the back ground of invention section. Composite and plastic tubular lever interfaces **20** can be more efficiently produced at a greatly improved accuracy and precision over their wood counterparts. This accuracy is especially demanded by the moveable knuckle visual location system **190** with small notches, pointers, and graduation marks that must yield accuracy within about 0.05 mm. Additionally, composite material with filler additives provide the capability for increased stiffness of the parts, which is extremely important to the responsiveness and touch weight requirement of any piano. Best mode tubular lever interfaces **20** are made of 6/6 Nylon with 50% long glass fiber. This material is currently considered the best mode because it yields the best combination of performance and cost. As the cost of composites or plastics with different filler materials fluctuates with economic trends, a new best mode material will likely be chosen.

Best mode hammer shanks **30** include a range of three types of tubes to retrofit one grand piano. The strongest shanks **30** are required in the bass end of the piano **45** because hammers **40** are heaviest at this end. Very strong shanks **30** are required to minimize deflection in the bass keys. In the treble end, hammers **40** are much lighter, thus stronger and heavier shanks **30** are not required. The weight of a heavy shank **30** in treble keys is undesirable because the additional weight in turn adds unnecessary leverage to the key **10** and thereby increases touch weight of the key **10**. In this instance, the shank **30** itself would act to dampen the motion of the hammer **40**. Thus, a lighter, less rigid shank **30** may be used in the treble end of the piano **45** as compared to the bass end. Because the bass shanks and the treble shanks are so different in mass, we utilize a transitional shank that has the same outside diameter as the bass but with a thinner wall thickness so as to bring the overall shank weight closer to that of the treble. The best mode comprises three different composite shanks **30** of tapering mass resulting in a powerful piano while also smooth in its transitions from key to key. Taking into account that shanks **30** with different outside diameters require different tubular lever interfaces **20** with corresponding diameter deep socket holes **200**, one mode of this invention includes the use three different shanks **30** with the same outside diameter to retrofit one grand piano using one style of tubular lever interface **20**.

What is claimed is:

1. A hammer assembly for a grand piano comprising:

a hammer, capable of striking a piano wire to produce a musical piano tone;

a hammer shank (**30**), comprising an oblong shaped member with a first end and a second end;

a moveable knuckle (**240**), comprising a cylindrically shaped member with a center line (**246**) that is the vertical bisection of the circular cross-section of said moveable knuckle; and

a tubular lever interface (**20**), comprising a hinge lever fixture with a hinge end, an oblong rigid body, a fixture end, a bottom, a top, a front, and a back, further comprising, a deep socket (**200**) at said fixture end, a set of two hinge pin attachment holes (**220**) at said hinge end, a void area (**230**) at said hinge end, and a moveable knuckle visual location system (**190**) at said bottom, said front, or said back, wherein,

said two hinge pin attachment holes are each coaxial and concentric with a hammer shank center-of-rotation (**185**) axis and each function to accept one end of a hinge pin,

said void area is located between said two hinge pin attachment holes and functions to allow clearance for the male hinge portion of a shank flange during rotation of said tubular lever interface,

said hammer is permanently affixed to said first end of said hammer shank,

said tubular lever interface is permanently affixed to said second end of said hammer shank by insertion into said deep socket, and

said moveable knuckle is permanently affixed to said bottom of said tubular lever interface, adjacent to said moveable knuckle visual location system.

2. A hammer assembly for a grand piano as in claim **1** wherein said deep socket has sufficient depth to allow for said hammer shank to be inserted and affixed inside of said deep socket to a depth that surpasses the position of said knuckle center line (**246**) to provide a lever and fulcrum arrangement wherein said hammer shank (**30**) functions as a lever to pry upwards and around the hammer shank center-of-rotation (**185**), which functions as a fulcrum.

3. A hammer assembly for a grand piano as in claim **1** wherein said moveable knuckle further comprises: a spline (**241**); a resilient core (**242**); a synthetic buckskin wear surface (**243**), and a moveable knuckle visual location system (**190**).

4. A hammer assembly for a grand piano as in claim **2** wherein said spline further comprises: an upright rectangular portion (**239**) and a wide base portion (**244**).

5. A hammer assembly for a grand piano as in claim **2** wherein said moveable knuckle can be located on and affixed to said tubular lever interface at any one of multiple distinct locations along a linear range that runs parallel to the length of said hammer shank and the length of said tubular lever interface to yield said hammer assembly with a specific tubular interface lever center-to-center dimension (**150**) of 14-20 millimeters with 0.5 millimeter increments between said multiple distinct locations.

6. A hammer assembly for a grand piano as in claim **2** wherein said moveable knuckle visual location system further comprises: a set of graduation marks (**198**) on a side of said tubular lever interface and at least one location mark (**248**) on a side of said moveable knuckle wherein said tubular lever interface and said moveable knuckle can be connected to yield said hammer assembly with a specific tubular lever interface center-to-center dimension (**150**) of 14-20 millimeters wherein said marks visually indicate the specific tubular lever interface center-to-center dimension (**150**) by designation of the alignment of one of said set of graduation marks with one said at least one location mark.

7. A hammer assembly for a grand piano as in claim **2** wherein said moveable knuckle visual location system further comprises: at least one pointer (**194**) on the bottom surface of said moveable knuckle and a set of several notches (**192**) on the bottom surface of said tubular lever interface, wherein said at least one pointer and each notch of said set of several notches are sized to fit snuggly together, each having essentially the same width.

8. A hammer assembly for a grand piano as in claim **2** wherein said hammer shank, said tubular lever interface, and said spline are made of plastic or composite material.

9. A hammer assembly for grand piano as in claim **6** wherein said hammer shank is of hollow cylindrical form.

10. A hammer assembly for a grand piano as in claim **2** wherein said moveable knuckle visual location system further comprises a knuckle intricate shape (**245**) on the bottom surface of said moveable knuckle, which comprises: at least one recess area (**249**) and at least one protrusion area (**247**).

11. A hammer assembly for a grand piano as in claim **8** wherein said knuckle intricate shape further comprises: at least one pointer (**194**), which fits snuggly into one of a set of several notches (**192**) within a tubular lever interface intricate shape (**196**) on the bottom surface of said tubular lever interface.

12. A hammer assembly for a grand piano as in claim **9** wherein said tubular lever interface intricate shape further comprises: at least one protrusion area (**197**), which is essentially the inverse shape of said at least one recess area on moveable knuckle (**249**), and at least one recess area (**199**), which is essentially the inverse shape of said at least one protrusion area on moveable knuckle (**247**).

13. A hammer assembly for a grand piano as in any of the preceding claims wherein said hammer shank and said tubular lever interface are made of plastic with glass fiber, carbon fiber, Kevlar fiber, or ceramic filler material.

14. A tubular lever interface for a grand piano as in claim **11** that is made of Nylon plastic with 40-60% glass fiber filler material.

15. A method to assemble a hammer assembly for a grand piano as in claim **11** comprising the steps of: affixing the first end of said hammer shank to said tubular lever interface at said deep socket; affixing said moveable knuckle to said tubular lever interface at said moveable knuckle location system; and affixing the second end of said hammer shank to said hammer.

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