Feb. 9, 1965 C. B. SMITHSON 3,168,834

MOTION CONVERTING MECHANISM

Filed Aug. 29, 1962 3 Sheets-Sheet 1

Fig. 1.

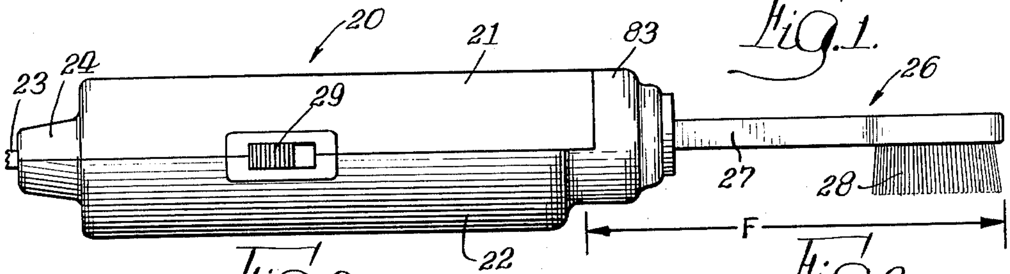


Fig. 2.

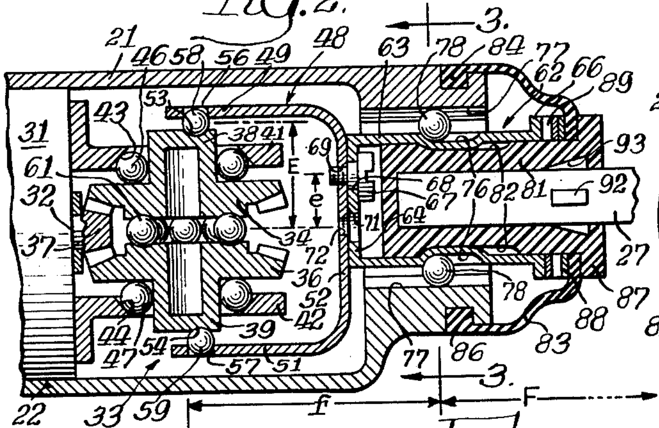


Fig. 3.

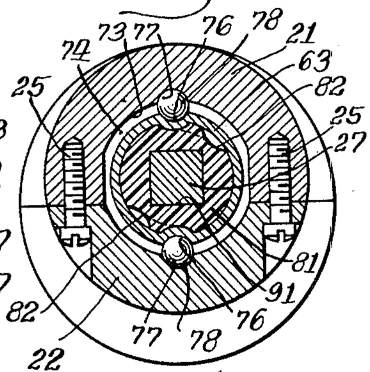


Fig. 4.

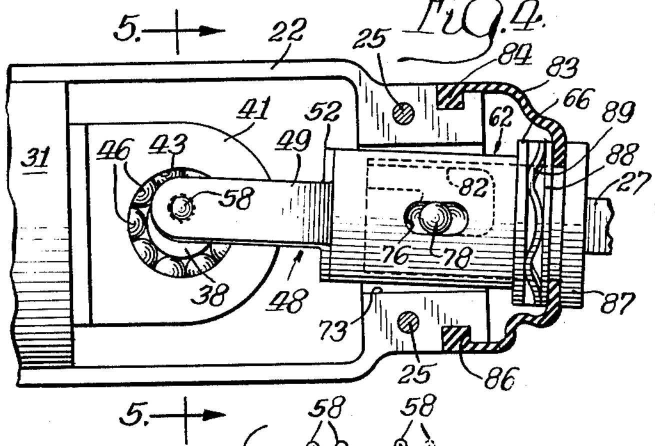


Fig. 5.

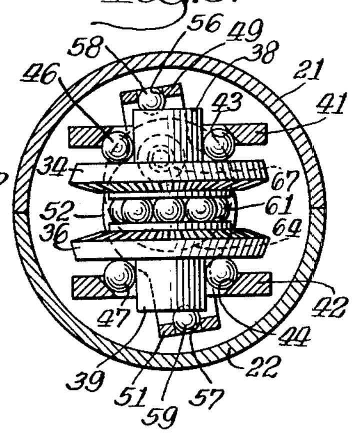
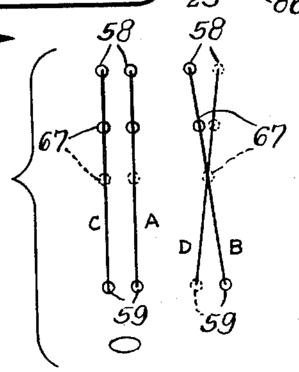


Fig. 6.



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MOTION CONVERTING MECHANISM

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Fig. 7.

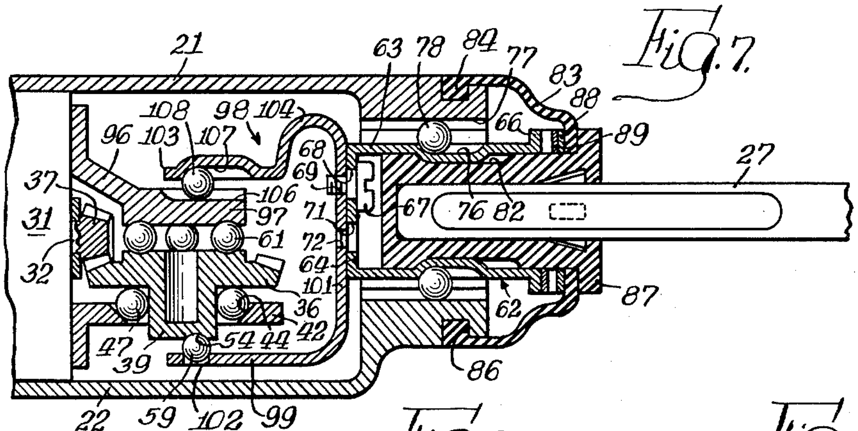


Fig. 8.

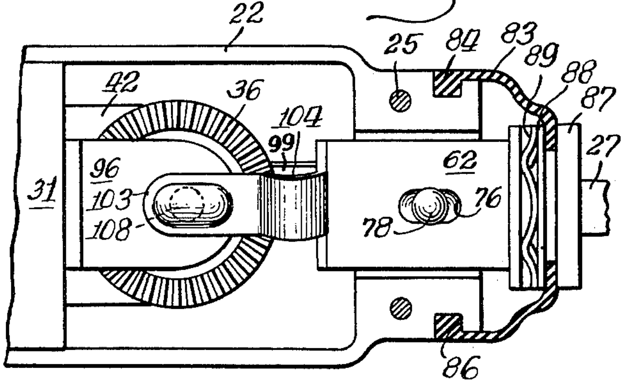


Fig. 10.

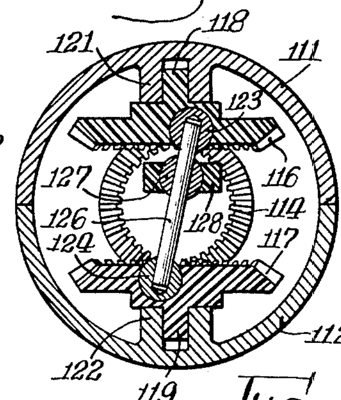
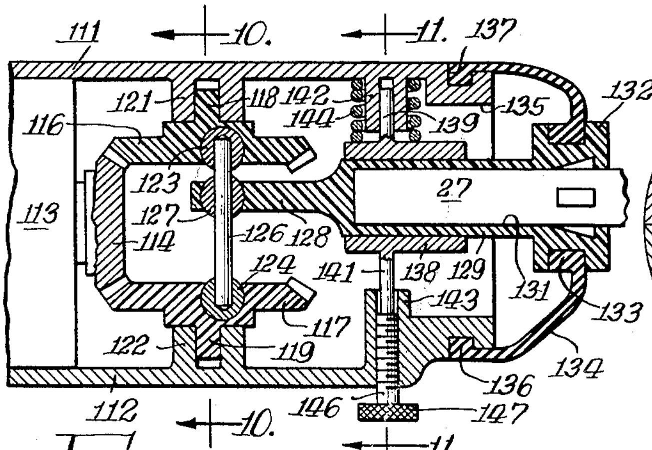


Fig. 11.



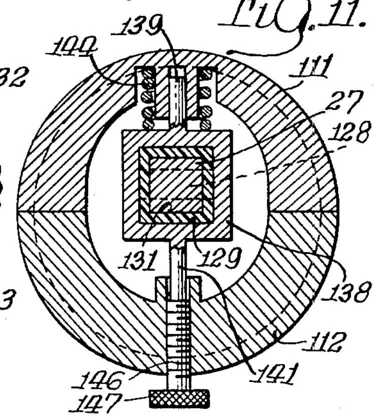


Fig. 9.

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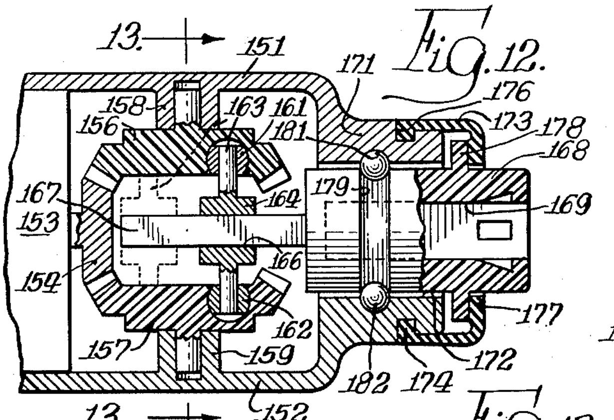

Fig. 12.

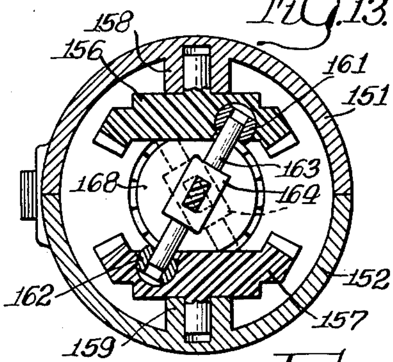

Fig. 13.

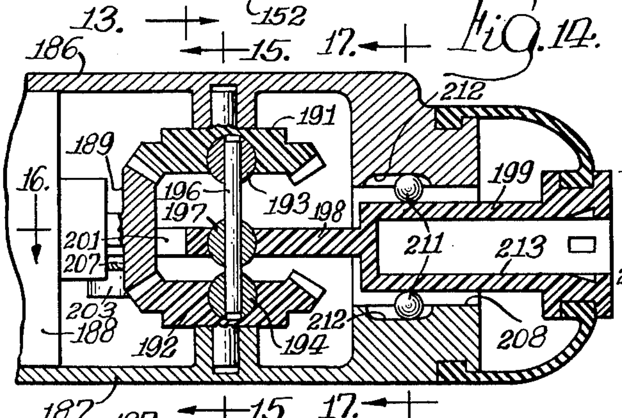

Fig. 14.

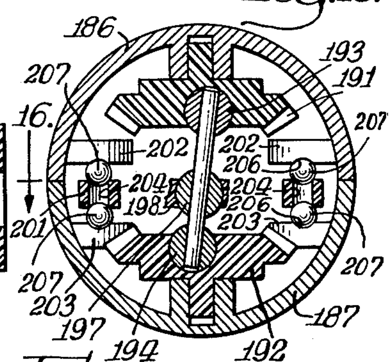

Fig. 15.

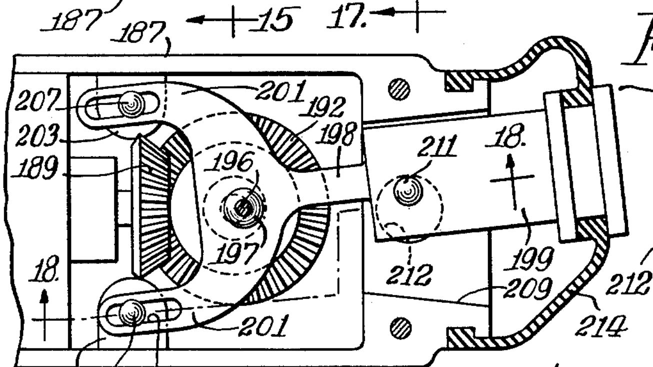

Fig. 16.

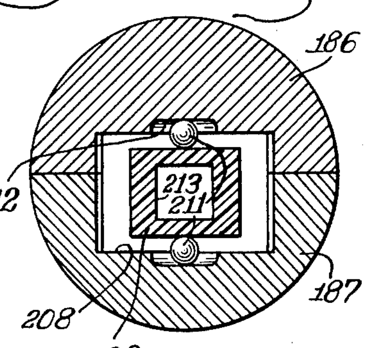

Fig. 17.

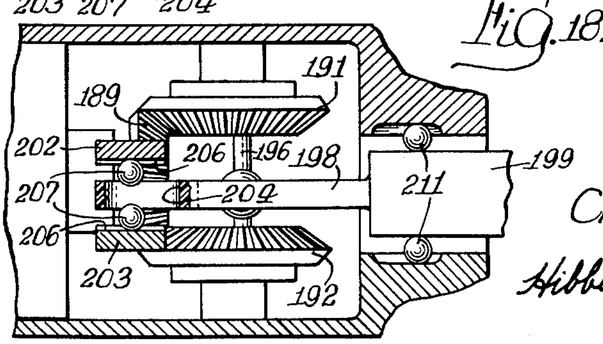

Fig. 18.

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3,168,834
MOTION CONVERTING MECHANISM

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Filed Aug. 29, 1962, Ser. No. 220,238
20 Claims. (Cl. 74—23)

This invention relates to improvements in power driven devices generally and more particularly to an improved power driven tool or hand implement such as a toothbrush. More specifically, the invention relates to a novel and improved motion converting means for use in a power driven device.

Various mechanisms have been suggested for power driven toothbrushes whereby the rotary motion of a motor shaft is converted to some type of reciprocating, oscillatory, or orbital motion at the brush or working end of the device. However, the devices heretofore known have had certain disadvantages which have restricted their commercial development and exploitation. For example, the previously known devices have been limited in power output or have been excessive in size in many instances. Furthermore, the motion converting or translating mechanism of such devices has usually been limited with respect to the type of output motion which can be obtained. In addition, in many instances it has been necessary to mount the motor with its drive shaft extending transversely of the longitudinal axis of the casing in order to obtain a desired type of motion at the working end of the device.

The present invention is designed to overcome the foregoing disadvantages by means of a novel and improved motion converting or translating mechanism.

Accordingly, a primary object of the invention is to provide a novel and improved motion converting mechanism for a power driven device, particularly a hand tool or implement.

Another object of the invention is to provide a novel and improved motion converting mechanism for a power driven device which is capable of providing a variety of desired motions at the working end of the device.

A further object of the invention is to provide an improved power driven device having a novel and improved motion converting mechanism characterized by a powerful but compact structure such that the mechanism is particularly useful in a power driven hand tool or implement.

An additional object of the invention is to provide a novel and improved motor driven device wherein the motor is mounted with its drive shaft extending longitudinally of the device and a motion translating mechanism is provided which is capable of converting rotary motion of the drive shaft to a predetermined type of straight line, oscillatory, or orbital motion, or combinations thereof, at the working end of the tool.

Other objects and advantages of the invention will become apparent from the subsequent detailed description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a reduced scale side elevational view of a power driven toothbrush constituting one specific embodiment of the invention;

FIG. 2 is an enlarged vertical sectional view at the forward end portion of the tooth brush illustrated in FIG. 1;

FIG. 3 is a transverse sectional view taken along the line 3—3 of FIG. 2;

FIG. 4 is a plan view of the interior of the toothbrush with the upper half of the casing removed and the gear mechanism revolved 90° from the FIG. 2 position;

FIG. 5 is a transverse sectional view taken along the line 5—5 of FIG. 4;

FIG. 6 is a schematic view illustrating the different positions of the mechanism shown in FIGS. 2 and 5;

FIG. 7 is a vertical sectional view similar to FIG. 2 but showing a modified form of the invention;

FIG. 8 is a plan view of the interior of the structure shown in FIG. 7 with the upper half of the casing removed and the gear mechanism revolved 90° from the FIG. 7 position;

FIG. 9 is a vertical sectional view similar to FIGS. 2 and 7 but showing another embodiment of the invention;

FIG. 10 is a transverse sectional view taken along the line 10—10 of FIG. 9 with the gear mechanism revolved 90° from the FIG. 9 position;

FIG. 11 is a transverse sectional view taken along the line 11—11 of FIG. 9;

FIG. 12 is a vertical sectional view similar to FIGS. 2, 7 and 9 but showing still another embodiment of the invention;

FIG. 13 is a transverse sectional view taken along the line 13—13 of FIG. 12 with the gear mechanism revolved 90° from the FIG. 12 position;

FIG. 14 is a vertical sectional view similar to FIGS. 2, 7, 9, and 12 but showing still another embodiment of the invention;

FIG. 15 is a transverse sectional view taken along the line 15—15 of FIG. 14 with the gear mechanism revolved 90° from the FIG. 14 position;

FIG. 16 is a horizontal sectional view taken along the line 16—16 of FIG. 14 but with the mechanism in a different position;

FIG. 17 is a transverse sectional view taken along the line 17—17 of FIG. 14; and

FIG. 18 is a fragmentary vertical sectional view taken substantially along the line 18—18 of FIG. 16.

In FIGS. 1–6, one specific embodiment of the invention is illustrated comprising, in this instance, a power driven toothbrush. Although, for the sake of convenience, the invention is hereinafter described in connection with a toothbrush, it is to be understood that the principles of the invention, including the novel motion converting mechanism, may also be used for other types of power driven devices, particularly tools and implements such as a saw, file, polisher, sander, etc.

As seen in FIG. 1, the toothbrush comprises an elongated housing or casing **20** of suitable plastic or other nonconductive material, the casing having detachable upper and lower halves **21** and **22**, respectively, which are held together by screws **25**. An electric power cord **23** extends from a reduced portion **24** at the rear end of the casing **20**, and a detachable toothbrush **26** having a shank portion **27** and a brush portion **28** is mounted at the forward or nose end of the casing **20**. A hand switch **29** projects from one side of the casing **20** for starting and stopping the drive of the toothbrush. Instead of electric power from the cord **23**, it will be understood that the casing **20** could be provided with a self-contained power supply such as a battery or the like.

Referring to FIGS. 2–5, an elongated cylindrical motor **31** is mounted within the casing **20** with its drive shaft **32** (FIG. 2) extending longitudinally or axially of the casing **20**. The rotary motion of the motor drive shaft **32** is converted to a predetermined desired type of motion at the brush **28** by means of a motion converting or translating mechanism indicated generally at **33** and comprising the principal novel feature of the present invention. A pair of spaced coaxial bevel gears **34** and **36** are driven in opposite directions by means of a pinion **37** mounted on the motor shaft **32**. The gears **34** and **36** are provided with hub portions **38** and **39**, respectively, which are journaled in a pair of upper and lower brackets **41** and **42**, respectively. The brackets **41** and **42** are rigidly secured to the motor **31** and extend forwardly therefrom in transversely spaced relation, as best seen in FIG. 2. The brackets **41** and **42** are provided with beveler openings 43 and 44, respectively, with a plurality of radial ball bearings 46 and 47 being disposed in the respective openings for journaling the hub portions 38 and 39 of the gears and retaining the latter in driving relation with the pinion 37.

The power take-off from the gears 34 and 36 is provided by means of a resilient yoke 48 of spring metal or the like having a pair of upper and lower arms 49 and 51, respectively, which are interconnected by a laterally enlarged central bight portion 52. The outer axial ends of the gear hubs 38 and 39 are provided with restricted sockets 53 and 54, respectively, and the outermost end portions of the yoke arms 49 and 51 are provided with restricted apertures 56 and 57, respectively, to accommodate a pair of balls 58 and 59 therebetween. As best seen in FIG. 2, the sockets 53 and 54 are disposed to one side of or in eccentric relation to the axis of rotation of the ring gears 34 and 36. The spring pressure exerted by the resilient yoke 48 holds the balls 58 and 59 in driving relation between the gear hubs 38, 39 and the corresponding yoke arms 49, 51. A plurality of ball bearing elements 61 are in rolling engagement between the opposed inner faces of the gears 34 and 36 for receiving the axial thrust of the gears.

As hereinatfer described in more detail, the rotary motion of the pinion 37 on the motor drive shaft is converted by the motion converting means 33 to a combined reciprocating and rocking movement of the yoke 48. This combined motion of the yoke 48 is transmitted to an outer socket member 62 having a cylindrical side wall 63, an inner axial end wall 64 abutting the yoke center portion 52, and an outwardly extending flange 66 at the open end of the socket. In this embodiment, a loose swivel connection is provided between the yoke center portion 52 and the socket end wall 64 by means of a shoulder screw 67 extending through an enlarged unthreaded opening 68 in the end wall 64 and engaged in a threaded opening 69 in the yoke portion 52. As will be evident from FIG. 2, the aligned openings 68 and 69 are off-center or eccentric with respect to the center line of the motor shaft 32 and the yoke 48. For a purpose to be described hereinafter, the socket end wall 64 and the yoke portion 52 are also provided with an enlarged unthreaded opening 71 and a smaller threaded opening 72, respectively, which are coaxial with the drive shaft 32 and the center line of the yoke 48.

The outer socket member 62 has a shiftable fulcrum arrangement so as to permit both straight line reciprocating movement of the socket 62 and also side-to-side pivotal movement. Thus, the forward or nose end of the casing 20 has an enlarged end opening 73 through which the outer socket 62 extends with an annular clearance space 74 (FIG. 3) therebetween. The cylindrical wall 63 of the outer socket 62 is provided with a pair of opposed axially extending grooves 76, and a cooperating pair of grooves 77 are provided in the housing opening 73. A pair of rollable ball elements 78 are interposed between the two sets of grooves. Accordingly, the outer socket member 62 which is connected to the yoke 48 can move back and forth in a longitudinal direction and at the same time the socket 62 can pivot from side to side about the balls 78 as a movable fulcrum within the confines of the annular clearance 74.

For detachably receiving the shank 27 of the toothbrush 26, an inner cylindrical socket member 81 of plastic or the like is detachably secured within the outer socket member 62 by means of a bayonet slot construction 82 having an interlocking relation with the inwardly depressed portions of the outer socket wall 63 which define the grooves 76. A flexible seal or boot 83 of rubber or other suitable material encloses the forward or nose end of the casing 20 and is secured to the latter by means of an annular flange or bead portion 84 which is seated snugly in a circumferential groove 86 encircling the nose end of the casing. The opposite end of the seal 83 is

clamped between the flange 66 of the outer socket 62 and a flange 87 on the inner socket member 81 by means of a flat washer 88 and a resilient spring wave washer 89. The spring action of the resilient washer 89 also serves to retain the inner socket member 81 in engaged relation within the outer socket member 62 while at the same time permitting the two socket members to be disconnected by pressing the socket member 81 axially inwardly and rotating the same to disengage the bayonet slot connection 82. Upon withdrawal of the inner socket member 81, the shoulder screw 67 becomes accessible for the purpose hereinafter described. The inner socket member 81 is provided with a square opening 91 for receiving the correspondingly shaped shank 27 of the toothbrush 26, the shank 27 being releasably retained in the socket member 81 by means of a plurality of depressible detents 92 on the shank 27 which are engageable with cooperating recesses 93 at the inner walls of the socket member 81.

To understand the motion of the yoke 48 of the motion converting mechanism 33, it is helpful to consider an imaginary filament or line stretched between the centers of the power take-off ball elements 58 and 59. As the gears 34 and 36 rotate in opposite directions, the power take-off balls 58 and 59 are driven in opposite circular paths so that the imaginary line undergoes a compound movement including a back-and-forth reciprocating motion longitudinally of the casing 20 and also an oscillating or rocking movement transversely of the casing 20 about the axial center line of the motor shaft 32 as a pivot center. However, regardless of the longitudinal displacement of the imaginary line or its transverse inclination, the imaginary line is always perpendicular to the axial center line through the motor shaft 32.

In FIG. 2, the power take-off balls 58 and 59 are shown in their extreme forward position wherein the power take-off balls are disposed vertically one above the other so that the yoke 48 is displaced forwardly the maximum distance of its stroke. This condition of the power take-off is illustrated schematically in FIG. 6 by the position A of the imaginary line extending between the power take-off balls. As the gears 34 and 36 rotate 90° from the FIG. 2 position to the position shown in FIGS. 4 and 5, the imaginary line between the power take-off balls 58 and 59 is retracted rearwardly in the casing one-half of its maximum displacement distance and at the same time the imaginary line is inclined in a transverse plane to the position indicated at B in the schematic view of FIG. 6. As the gears 34 and 36 rotate another 90°, the balls 58 and 59 and the imaginary line therebetween again assume a vertical position but are now disposed at their extreme rearwardmost position, as indicated schematically at C in FIG. 6. Continued rotation of the gears 34 and 36 through another 180° to complete a single revolution will cause the imaginary line between the balls 58 and 59 to pass through an oppositely inclined position, as indicated schematically at D in FIG. 6, and finally to return to their FIG. 2 position, as shown at A in FIG. 6.

As will be evident from the foregoing, during the above described cycle the opposite ends of the imaginary line or filament will trace circles and the midpoint of the imaginary line will undergo a simple back-and-forth reciprocating movement along the axial center line of the motor shaft 32. In addition, any point on the imaginary line between the midpoint thereof and one of the extreme ends thereof will trace an ellipse whose major axis has the same dimension as the diameter of the circles traced by the ends of the line and whose minor axis depends on the distance of the point in question from the axial center line of the motor shaft. Consequently, when the yoke 48 of the motion converting mechanism 33 has a loose pivotal connection with the socket member 62 by means of the shoulder screw 67 and the aligned off-center holes 68 and 69, as shown in FIG. 2, it will be understood that the motion of the yoke 48 is being transmitted to the socket member 62 at an ellipse-generating point between the center and the upper end extremity of the imaginary line between the power takeoff balls 58 and 59.

As seen schematically in FIG. 6, the solid line position of the connecting shoulder screw 67 is substantially midway between the center of the imaginary line and the upper extremity defined by the power take-off ball 58. Thus, the power take-off point 67 from the yoke 48 generates an ellipse, as illustrated at the bottom of FIG. 6, whose major axis is the same as the distance between the lines A and C and whose minor axis is the same as the maximum displacement distance of the take-off point 67 in the oppositely inclined positions of the lines B and D. Because of the loose pivotal connection between the yoke 48 and the socket member 62 and because the socket member 62 is restrained from rotating about its central longitudinal axis by reason of the coaction between the fulcrum balls 78 and their grooves 76 and 77, the elliptical motion generated at the inner end of the socket 62 is substantially reproduced at the brush 28. However, the dimensions of the minor axis of the ellipse will be altered depending upon the relative distances between the shiftable fulcrum and the opposite ends of the moving mechanism comprising the socket wall 64 and the brush 28. By properly proportioning these distances, it is possible to obtain at the brush a motion that is substantially elliptical or substantially circular, either of which paths may be described generically as orbital or as having both longitudinal and lateral components.

Referring to FIGS. 1 and 2, substantially circular motion of the brush 28 or other tool will result if the ratio $e:E$ is the same as the ratio $f:F$, where e is the distance from the axial center line of the motor shaft 32 to the center of the shoulder screw 67, E is the distance from the same center line to the center of the eccentric power take-off ball 58 or 59, f is the distance from the axis of rotation of the gears 34 and 36 to the movable fulcrum point 78, and F is the distance from the tool point or brush 28 to the same movable fulcrum 78. If the ratios $e:E$ and $f:F$ are different, a substantially elliptical or non-circular orbital motion will be obtained.

It will also be understood that if the shoulder screw 67 is installed through the aligned openings 71 and 72 which are on the center line of the motor shaft 32, the lateral component of movement of the yoke 48 is completely canceled out and the brush 28 undergoes straight line reciprocating movement longitudinally of the casing 20. This condition is also shown schematically in FIG. 6 at the dotted line position of the screw 67 from which it will be seen that the maximum reciprocating distance comprises the distance between the lines A and C, but in a transverse plane the movement of the imaginary line between positions B and D causes no lateral displacement of the power take-off point 67. Thus, by locating the shoulder screw 67 in the desired set of holes and by properly proportioning the lengths of the pivot arms extending in opposite directions from the shiftable fulcrum 78, it is possible to obtain in a single tool either straight line reciprocating movement or any desired type of orbital movement, including circular and elliptical paths.

Because of the square configuration of the socket opening 91 and the corresponding configuration of the tool brush shank 27, it is possible by properly orienting the brush handle in the socket to take advantage of orbital motion of the brush in several different ways without changing the position of the casing 20. This characteristic may have particular importance in the case of certain types of tools or implements other than a toothbrush. For example, with the device in the position shown in FIG. 1, the orbital motion at the brush 28 can be used for full or continuous contact polishing, sanding or cleaning of a top surface or the like. By reversing the position of the brush member 180° so that the brush portion or other tool point extends upwardly instead of downwardly, the same type of continuous or full contact may be obtained for working on the underside of a surface or the like. In the case of a different type of tool or implement, such as a saw blade or file, the square shank of the tool can be oriented in the inner socket 81 so that the orbital motion is imparted to the tool point in a vertical plane instead of in a horizontal plane as in FIG. 1. Thus, the tool point will have a rolling or stroking motion relative to the work which would provide for automatic cleaning on the return stroke in the case of a saw blade or file.

It will also be evident that with the motion converting mechanism 33, still other modifications may be realized to obtain additional types of output motions. For example in FIG. 2 the outer socket 62 may be rotatably supported in the casing opening 73 by suitable annular bearing means and may also be rigidly connected to the yoke portion 52 with the longitudinal axis of the socket in coaxial relation with the motor shaft 32. With this modification, it will readily be understood that the socket member 62 will undergo straight back and forth reciprocating movement combined with oscillating rotary movement about its longitudinal axis. This motion is particularly useful for chip clearance and removal in a drill-type boring tool.

The use of a pair of opposed gears 34 and 36 in the manner described has special advantage in the case of relatively small hand tools or implements because of the compactness of the design which at the same time permits the motor 31 to be mounted in longitudinal relation in the casing 20. Inasmuch as only one-half the total power output is being taken from each gear, the gears can be made substantially smaller than would otherwise be the case thereby realizing a compact construction without sacrificing power output.

FIGS. 7 and 8 illustrate a modification of the motion converting mechanism 33 heretofore described. Those portions of the structure which are essentially the same as in FIGS. 1 to 5 are identified by the same reference numerals in FIGS. 7 and 8. In this modification the upper gear 34 of the first embodiment has been eliminated and in place thereof a bracket 96 has been substituted, the bracket having a horizontal portion 97 extending rigidly from the end of the motor 31 and being provided at its underside with a suitable raceway for the thrust ball elements 61. The spring yoke member in this instance is designated generally at 98 and has a lower arm 99 and a central portion 101 which are essentially the same as the arm 51 and the portion 52 in the first described embodiment. The lower arm 99 has a restricted opening 102 for receiving the power take-off ball 59 in the manner previously described. The central portion 101 of the yoke 98 has the same connection with the outer socket member 62 which need not be described in further detail.

At the upper end of the yoke 98 a horizontal arm portion 103 is disposed adjacent the bracket portion 97 and is integrally connected to the central yoke section 101 by means of an inverted U-shaped connecting portion 104. The bracket portion 97 and the opposed yoke arm 103 are provided with confronting grooves 106 and 107, respectively, and a ball bearing element 108 is disposed therebetween. The groove 106 is arranged parallel to the axial center line of the motor shaft 32 so that as the eccentric power take-off ball 59 undergoes circular movement during rotation of the ring gear 36, the ball bearing element 108 supports the yoke arm 103 for back-and-forth reciprocating movement while at the same time accommodating transverse rocking or swivel movement of the yoke arm 103 about the ball element 108. Thus, with the use of only a single gear 36 driven by the pinion 37, the same selective straight line or orbital movement may be obtained from the motion converting mechanism. However, in this case the shoulder screw openings 68 and 69 are aligned axially with the center line of the path of reciprocating movement of the ball 108 and with the shoulder screw 67 in these openings the socket 62 undergoes straight reciprocating movement. When the openings 71 and 72 are utilized, orbital motion is obtained.

FIGS. 9 to 11 illustrate another embodiment of the invention utilizing a different socket fulcrum arrangement and a different power take-off means from the rotating gear. The casing comprises two sections 111 and 112 housing a motor 113 which drives a pinion gear 114. A pair of bevel gears 116 and 117 of plastic or the like have integral hub portions 118 and 119, respectively, which are journaled in tubular bosses 121 and 122, respectively, projecting from the wall of the casing. The gears 116 and 117 are driven in opposite directions by the pinion 114.

A pair of metal swivel balls 123 and 124 are rotatably mounted in corresponding sockets in the gears 116 and 117 in eccentric relation with respect to the axis of rotation of the gears and projecting slightly from the opposed faces of the gears. The balls may be molded in place during fabrication of the plastic gears and thereafter may be broken free of the plastic material. The sockets are then suitably lubricated to permit free swivel movement of the balls. The balls 123 and 124 are interconnected by means of a shaft segment or pin 126 which performs the essential function of the yoke 48 or 98 in the previously described embodiments of the invention. The opposite ends of the pin 126 are slidable in suitable bores in the balls 123 and 124 to accommodate rotation of the gears. An intermediate swivel ball element 127 is axially bored and is slidably and adjustably mounted on the pin 126 intermediate the end ball elements 123 and 124. The swivel ball element 127 is also rotatably retained in swivel relation in a complementary socket portion formed at the inner end extension 128 of a plastic socket member 129 having a square or non-circular external cross-section. The socket member 129 is also provided with an inner opening 131 of square cross-section for detachably receiving the toothbrush shank 27 or other tool in the same manner as heretofore described. The outermost end of the socket member 129 has a circumferentially grooved flange portion 132 for receiving the beaded end 133 of a flexible rubber seal 134. The opposite end 136 of the seal 134 is retained in a groove 137 at the end of the casing. As before, the function of the seal 134 is to enclose an enlarged opening 135 at the forward end of the casing and through which the socket member 129 extends.

In this instance, the fulcrum for the socket member 129 comprises a square tubular section 138 having the square socket member 129 slidably disposed therein but restrained against rotation about its longitudinal axis. The fulcrum member 138 has oppositely extending integral shaft extensions or pin portions 139 and 141 which are rotatably journaled in and axially shiftable in a pair of tubular bearing bosses 142 and 143, respectively, extending inwardly from the casing. A coil spring 144 is interposed between one side of the fulcrum member 138 and the casing section 111 for urging the fulcrum member 138 toward the opposite casing section 112. An adjusting screw 146 is threaded into the tubular bearing boss 143 and has an enlarged head portion 147 disposed at the exterior of the casing for manipulating the same. The inner end of the screw 146 abuts the pivot pin 141 of the fulcrum member 138. By reason of the slidable relationship between the swivel ball 127 and the shaft segment 126, it will be seen that the position of the swivel ball element 127 relative to the rotating ball elements 123 and 124 can readily be adjusted by means of the screw 146 which regulates the transverse position of the fulcrum member 138.

By adjustment of the position of the swivel ball element 127, it will be understood that the power take-off point for the socket member 129 is correspondingly adjusted thereby determining the straight line or orbital character of the path of movement transmitted to the brush or other tool. When the swivel ball element 127 is located on the axial center line of the motor shaft, the socket member 129 will undergo a simple back-and-forth straight line reciprocating movement. However, when the swivel ball element 127 is located in a position intermediate the motor shaft center line and one of the balls 123 or 124, an orbital movement is transmitted to the brush which may be either circular or elliptical dependent upon the proportioning factors heretofore discussed. It will also be understood that if the ball 127 is located between the center line of the motor shaft and the ball element 123, the path of orbital movement will be in one direction, whereas if the ball element 127 is located between the motor shaft center line and the opposite swivel ball element 124, the path of orbital movement will be in the opposite direction. Thus, the invention provides a very simple and convenient method of reversing the direction of orbital movement of the tool point without the necessity for a reversible motor.

In the position of the motion converting mechanism shown in FIG. 9, the eccentrically located swivel ball elements 123 and 124 are disposed one above the other in a vertical line and are located at the point of maximum forward displacement. It will be understood that when the gears 116 and 117 have rotated 180° from the FIG. 9 position, the balls 123 and 124 will again be disposed one above the other in vertical relation but at the point of maximum rearward displacement. Consequently, a back-and-forth reciprocating movement is imparted to the socket member 129 longitudinally of the casing. At the same time, as the gears 116 and 117 rotate 90° and 270° from the FIG. 9 position, the ball elements 122 and 123 are disposed at opposite sides of the gear axis (FIG. 10) to impart a lateral component of movement in a plane transversely of the casing.

A further variation in this type of motion at the brush or tool point may be obtained by locating the swivel balls 123 and 124 on the gears 116 and 117 so that vertical alignment of the balls is obtained when the balls are disposed adjacent opposite sides of the casing in a transverse plane therethrough. With this relationship, it will be seen that the center point of the pin 126 undergoes lateral back-and-forth movement in a straight line transversely of the casing, and if the swivel ball 127 is located at the center point of the pin 126, a similar lateral back-and-forth swinging movement will be imparted to the brush or tool point. Actually, because of the pivoted fulcrum 138 the brush or tool point will have a slight arcuate path from side to side but the curvature is so minute that to the eye it will appear as a straight line. Thus, by varying the eccentric locations of the swivel balls 123 and 124 relative to the gears and to each other and by varying the location of the intermediate swivel ball 127 relative to the end balls 123 and 124, a wide variety of compound motions may be obtained at the brush or tool point.

FIGS. 12 and 13 illustrate a modification of the arrangement shown in FIGS. 9–11 whereby oscillatory movement of the tool socket and tool or brush about its center line is obtained. The casing has upper and lower halves 151 and 152 which contain a motor 153 having a pinion 154 on its shaft. A pair of plastic bevel gears 156 and 157 are journaled in tubular bosses 158 and 159 extending from the casing wall and are driven in opposite directions by the pinion 154 in the same manner as in the previous embodiment of FIGS. 9 to 11. Power take-off from the gears 156 and 157 is again accomplished by means of a pair of swivel balls 161 and 162 retained in swivel relation in corresponding socket portions in the gears 156 and 157 and interconnected by a shaft segment or pin 163 having its opposite ends slidably received in the balls 161 and 162. In this instance, however, the center portion of the shaft segment 163 is enlarged, as at 164, and the enlargement is provided with a rectangular opening 166 therethrough for slidably receiving an elongated rearward extension 167 of a plastic socket member 168.

The socket member 168 is cylindrical but has a rectangular opening 169 for detachably receiving the shank of a brush or other tool member in the manner previously described. The forward end of the casing has a reduced diameter nose portion 171 with an opening 172 through which the socket 168 extends. A cup-shaped flexible rubber seal 173 has a flanged end 174 retained in a circumferential groove 176 around the outside of the nose portion 171, and the outer end of the seal 173 comprises an apertured wall or annular lip portion 177 in resilient engagement with an annular flange 178 extending integrally and outwardly from the socket member 168. The socket member 168 and the opening 172 are provided with opposed circumferential grooves 179 and 181, respectively, with a plurality of ball bearing elements 182 disposed therebetween for rotatably supporting the socket member.

The motion imparted to the shaft segment 163 by means of the oppositely rotating gears 156 and 157 is the same as in the embodiment of FIGS. 9–11. However, in this instance, the socket member 168 is restrained against longitudinal or axial movement by the ball elements 182 but is free to rotate about its central longitudinal axis. Consequently, the socket extension 167 remains in fixed position longitudinally of the casing but the enlarged section 164 of the shaft segment slides back and forth between the full line and dotted line positions shown in FIG. 12 as the gears 156 and 157 rotate. During rotation of the gears, the shaft segment 163 also rocks from side to side transversely of the casing between the full line and dotted line inclined positions shown in FIG. 13, and the keyed relationship between the shaft segment portion 164 and the socket extension 167 causes the socket 168 to oscillate back and forth about its longitudinal axis through an arc of about 60°. Accordingly, the tooth brush or other tool point undergoes the same rotary or oscillating movement.

A combination of the above-described oscillatory motion and straight axial reciprocation can also be obtained with the structure of FIGS. 12–13 by changing the support for socket 168 to permit both types of motion and at the same time rigidly connecting the socket extension 167 and the segment 163 at the center point of the latter.

FIGS. 14–18 illustrate a further modification of the embodiment of FIGS. 9–11 wherein the shiftable fulcrum for the socket is disposed rearwardly of the gear axis and the connecting shaft segment rather than forwardly thereof. The casing has upper and lower halves 186 and 187 with a motor 188 contained therein, a pinion 189 mounted on the motor shaft, and a pair of plastic gears 191 and 192 journaled in tubular bosses extending from the casing walls and driven in opposite directions by the pinion 189. The power take-off swivel ball elements are designated at 193 and 194 and are interconnected by a shaft segment 196 in the same manner as previously described. An intermediate swivel ball element 197 is provided on the shaft segment 196 and is retained in swivel relation in an elongated extension 198 projecting rearwardly from a socket member 199 of rectangular external shape. The socket extension 198 is fork shaped, as best seen in FIG. 16, and has a pair of laterally spaced arms 201 projecting rearwardly beyond the axis of the ring gears 191 and 192. Each arm 201 extends between a pair of upper and lower shoulders 202 and 203, respectively, provided in the casing. The arms 201 are slotted, as at 204, and the shoulders 202 and 203 are provided with corresponding grooves 206 with a pair of ball elements 207 disposed between each groove 206 and the confronting side of the slot 204. Thus, a pair of movable fulcrums are provided rearwardly of the power take-off connection which accommodate both back-and-forth reciprocating movement and side-to-side pivotal movement of the forked socket extension 198.

The nose end of the casing has a rectangular end opening 208 with outwardly tapering side wall portions 209 (FIG. 16) to accommodate side-to-side swinging movement of the socket member 199. Bearing support for the socket member 199 is provided by means of a pair of ball elements 211 seated in a pair of shallow circular recesses or sockets 212 and rollably engaging the flat upper and lower surfaces of the socket member 199. The circular recesses 212 are of relatively large diameter compared to the diameter of the balls 211 so as to accommodate combined back-and-forth reciprocating and side-to-side pivotal movement of the socket member 199.

As before, the socket member 199 has a square central opening 213 for detachably receiving the shank of a tooth brush or other tool member. Likewise, the forward end of the socket member 199 has a grooved construction similar to that shown in FIG. 9 and is provided with a flexible rubber seal 214 extending between the grooved end of the socket member and a similar groove in the nose of the casing.

As will be recognized, the location of the swivel ball element 197 along the shaft segment 196 is fixed in this instance so that the mechanism cannot be adjusted to provide either straight line or orbital movement, as may be desired. In the arrangement shown in FIGS. 14–18, the ball element 197 is located between the center line of the motor drive shaft and the lower swivel ball 194 so as to transmit an orbital motion to the socket member 199 in one direction. If the swivel ball 197 is located between the motor shaft center line and the upper swivel ball 193, and orbital path in the opposite direction is provided.

Although the invention has been described with particular reference to certain specific structural embodiments thereof, it should be understood that various alternatives and equivalent structures may be resorted to without departing from the scope of the invention as defined in the appended claims.

I claim:

1. Motion converting means for use in a power driven tool or the like comprising, in combination, a rotatably driven gear element, a power take-off member having spaced end portions, means providing a swivel driving connection between one of said end portions and said gear element in eccentric relation to the axis of rotation of said gear element, means axially spaced from said gear element providing a swivel support for the other of said end portions, means mounting said swivel support for movement of said other end portion relative to said axis during rotation of said gear element, and movably supported means connected to said power take-off member at an intermediate portion thereof between said end portions for receiving and transmitting the resultant motion of said power take-off member.

2. In a power driven device, the combination of an elongated housing, a motor in said housing having a drive shaft extending longitudinally of said housing, a drive gear element mounted on said shaft, a socket member movably supported at one end of said housing for mounting a tool or the like, and motion converting means interconnecting said drive gear element and said socket member, said motion converting means comprising a driven gear element meshed with said drive gear element and mounted for rotation in said housing on an axis extending transversely of said drive shaft, a power take-off member having spaced end portions, means providing a swivel driving connection between one of said end portions and said driven gear element in eccentric relation to said axis, means axially spaced from said driven gear element providing a swivel support for the other of said end portions, means mounting said swivel support for movement of said other end portion relative to said axis during rotation of said driven gear element, and means connecting said socket member to said power take-off

member at an intermediate portion thereof between said end portions.

3. In a power driven device, the combination of a motor driven shaft, a pinion on said shaft, a gear element mounted for rotation on an axis transverse to said shaft and meshed with said pinion, a yoke member having spaced arm portions and a central portion between said arm portions, means providing a swivel driving connection between one of said arm portions and said gear element in eccentric relation to said axis, means axially spaced from said gear element providing a movable swivel support for the other of said arm portions, and movably supported means connected to said central portion of said yoke member for receiving and transmitting the resultant motion of said yoke member.

4. In a power driven device, the combination of a motor driven shaft, a pair of spaced coaxial gear elements mounted for rotation on an axis transverse to said shaft, means driven by said shaft for rotating said gear elements in opposite directions, a power take-off member having spaced end portions, means providing a swivel driving connection between each of said end portions and one of said gear elements in eccentric relation to said axis, and movably supported means connected to said power take-off member at an intermediate portion thereof between said end portions for receiving and transmitting the resultant motion of said power take-off member.

5. In a power driven device including an elongated housing and a motor mounted in the housing with its shaft extending longitudinally of the housing, the combination of a pair of spaced coaxial gear elements mounted for rotation on an axis transverse to said shaft, a pinion on said shaft meshed with said gear elements for rotating the latter in opposite directions, a yoke member having resilient spaced arm portions disposed adjacent said gear elements and a central portion between said arm portions, means comprising a pair of ball elements in swivel engagement with said arm portions and the respective gear elements in eccentric relation to said axis for providing a driving connection between said gear elements and said yoke member, a socket member extending longitudinally of said housing and movably supported therein for mounting a tool or the like, and means connecting said socket member to said central portion of said yoke member.

6. The structure of claim 5 further characterized in that said socket member and said casing are provided with longitudinally shiftable fulcrum means for said socket member and means for restraining said socket member against rotation about its axis, and said socket member has an axial end wall pivotally connected to said central portion of said yoke member whereby to accommodate rocking of said yoke member relative to said socket member.

7. The structure of claim 6 further characterized in that said end wall portion of said socket member and said central portion of said yoke member are provided with one pair of aligned apertures disposed on the axis of said shaft and at least one other pair of aligned apertures offset from the axis of said shaft, and detachable pivot connecting means is provided for selective engagement in either pair of apertures whereby to provide either straight line reciprocating or orbital movement of said socket member.

8. In a power driven device including an elongated housing and a motor mounted in the housing with its shaft extending longitudinally of the housing, the combination of a gear element mounted for rotation on an axis transverse to said shaft, a pinion on said shaft meshed with said gear element for rotating the latter, a rigid support spaced axially from said gear element, a yoke member having resilient spaced arm portions disposed adjacent said gear element and said support, respectively, and a central portion between said arm portions, means comprising a first ball element in swivel engagement between one of said arm portions and said gear element in eccentric relation to said axis for providing a driving connection therebetween, means comprising confronting guide portions on said support and on the other of said arm portions and a second ball element received therebetween for providing a movable swivel support for said other arm portion, said guide portions being disposed so as to restrict movement of said second ball element in a straight path parallel to the axis of said shaft, a socket member extending longitudinally of said housing and movably supported therein for mounting a tool or the like, and means connecting said socket member to said central portion of said yoke member.

9. The structure of claim 8 further characterized in that said socket member and said casing are provided with longitudinally shiftable fulcrum means for said socket member and means for restraining said socket member against rotation about its axis, and said socket member has an axial end wall pivotally connected to said central portion of said yoke member whereby to accommodate rocking of said yoke member relative to said socket member.

10. The structure of claim 9 further characterized in that said end wall portion of said socket member and said central portion of said yoke member are provided with one pair of aligned apertures disposed in axial alignment with said path and at least one other pair of aligned apertures offset from said path, and detachable pivot connecting means is provided for selective engagement in either pair of apertures whereby to provide either straight line reciprocating or orbital movement of said socket member.

11. In a power driven device the combination of a motor driven shaft, a pinion on said shaft, a pair of spaced coaxial gear elements mounted for rotation on an axis transverse to said shaft and meshed with said pinion for rotating said gear elements in opposite directions, swivel means carried at the opposed faces of said gear elements in eccentric relation to said axis, an elongated connecting member extending between said gear elements with the opposite ends of said connecting member movably engaging said swivel means, and movably supported means connected to said connecting member at an intermediate portion of the latter between said ends for receiving and transmitting the resultant motion of said connecting member.

12. The structure of claim 11 further characterized in that said swivel means comprises a pair of ball elements having a swivel mounting in said gear elements and said connecting member comprises a pin with its opposite ends slidably received in said ball elements.

13. The structure of claim 12 further characterized in that said movably supported means comprises a socket member connected to said pin intermediate the ends of the latter by means slidably adjustable lengthwise of the pin and mounted in swivel relation to said socket member.

14. The structure of claim 12 further characterized in that said pin has an intermediate ball element slidably mounted thereon intermediate said pair of ball elements and said movably supported means comprises a socket member having an extension with said intermediate ball element mounted in swivel relation in said extension.

15. The structure of claim 14 further characterized by the provision of a tubular fulcrum support for slidably receiving said socket member and restraining the same against rotation about its axis, means pivotally mounting said fulcrum support on a pivot axis parallel to the axis of rotation of said gear elements, and means for adjusting the position of said fulcrum support transversely along said pivot axis whereby to provide simultaneous adjustment of the position of said intermediate ball element lengthwise of said pin.

16. The structure of claim 15 further characterized by the provision of a pair of pivots extending from opposite sides of said fulcrum support, means supporting said pivots for rotary and axial sliding movement, spring means

at one side of said fulcrum support for urging said fulcrum support in one direction, and threaded adjustment means at the opposite side of said fulcrum support for regulating the position of said fulcrum support and said socket member.

17. The structure of claim 12 further characterized in that said movably supported means comprises a socket member supported for rotary oscillation about its axis with means providing a non-rotatable but longitudinally slidable connection between said socket member and an intermediate portion of said pin.

18. The structure of claim 17 further characterized in that said pin has an enlarged intermediate portion with a non-circular aperture and said socket member has an elongated extension of non-circular cross-section slidably disposed through said aperture.

19. The structure of claim 12 further characterized in that said movably supported means comprises a socket member supported for orbital movement forwardly of said pin, a rearward extension on said socket member having a swivel connection with an intermediate portion of said pin and a pair of yoke arms projecting rearwardly beyond said pin, and means coacting with said yoke arms and providing a pair of oppositely disposed shiftable fulcrum supports for said yoke arms.

20. The structure of claim 19 further characterized in that said last-named means comprises guide portions confronting said yoke arms and ball means interposed therebetween.

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