United States Patent [19]

Eminger

[11] **3,821,903**

[45] **July 2, 1974**

[54] **MOTION CONVERSION APPARATUS**

[75] Inventor: **Robert J. Eminger,** Fort Wayne, Ind.

[73] Assignee: **Windamatic Systems Inc.,** Fort Wayne, Ind.

[22] Filed: **Apr. 4, 1973**

[21] Appl. No.: **347,715**

[52] **U.S. Cl.** **74/50,** 74/600

[51] **Int. Cl.** **F16h 21/18**

[58] **Field of Search** ..... 308/3 GH; 74/50, 40, 600

[56] **References Cited**

UNITED STATES PATENTS

534,600	2/1895	Davis et al.	74/40
586,973	7/1897	Koch	74/40
610,488	9/1898	Hugus	74/40
812,626	2/1906	Wilson	74/40
1,560,070	11/1925	McNamara	74/40
2,949,789	8/1960	Eminger	74/23

Primary Examiner—Samuel Scott

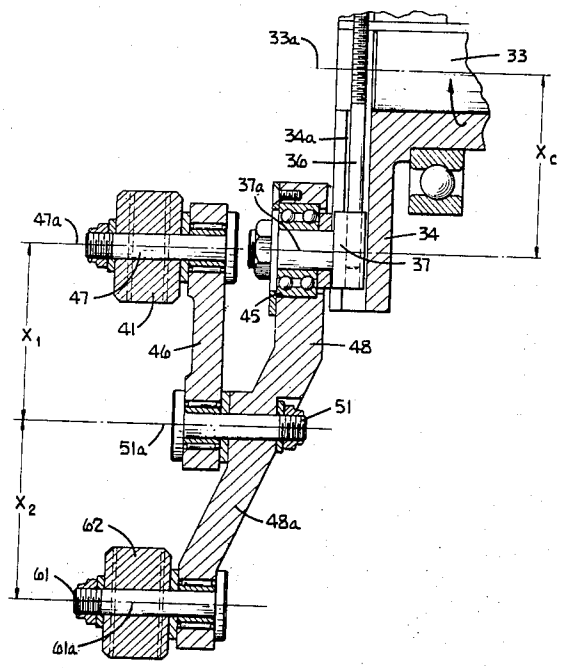
Assistant Examiner—Wesley S. Ratliff, Jr.

Attorney, Agent, or Firm—Woodard, Weikart, Emhardt & Naughton

[57] **ABSTRACT**

Disclosed is an apparatus for converting uniform rotation of a drive shaft into rectilinear harmonic motion of a cross head in which a crank, offset from the drive shaft, is connected to the cross-head by means of arms or links pivotally joined together and to the cross-head and crank. The cross-head and the extending end of one of the arms are constrained by guide means to move in a rectilinear path aligned with a diameter of the circular path in which the crank is moved by rotation of the drive shaft.

8 Claims, 9 Drawing Figures



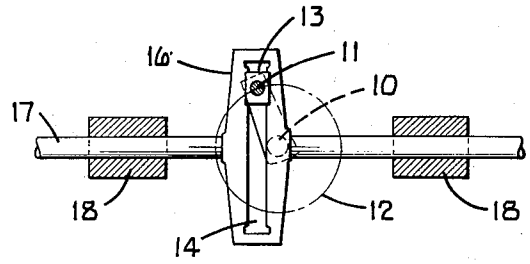


Fig.1 PRIOR ART

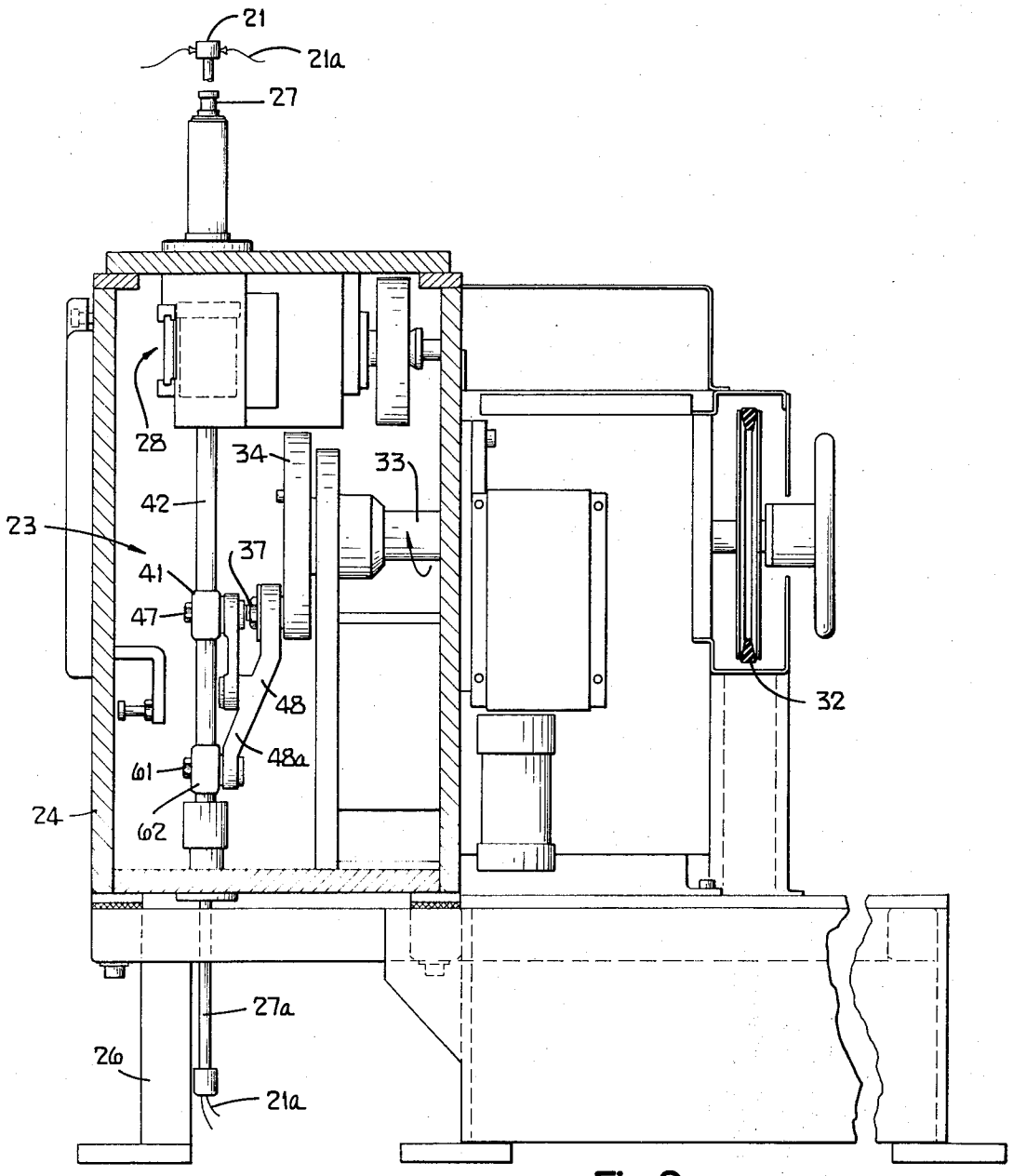


Fig.2

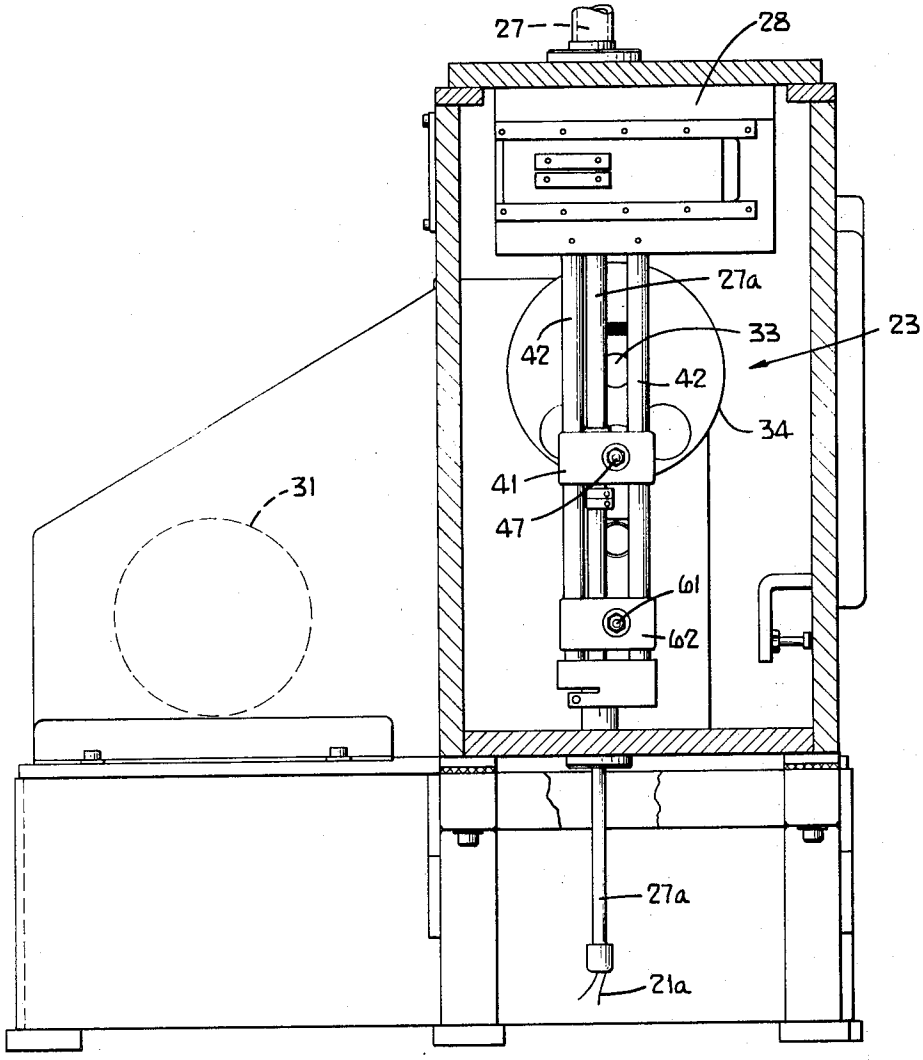


Fig.3

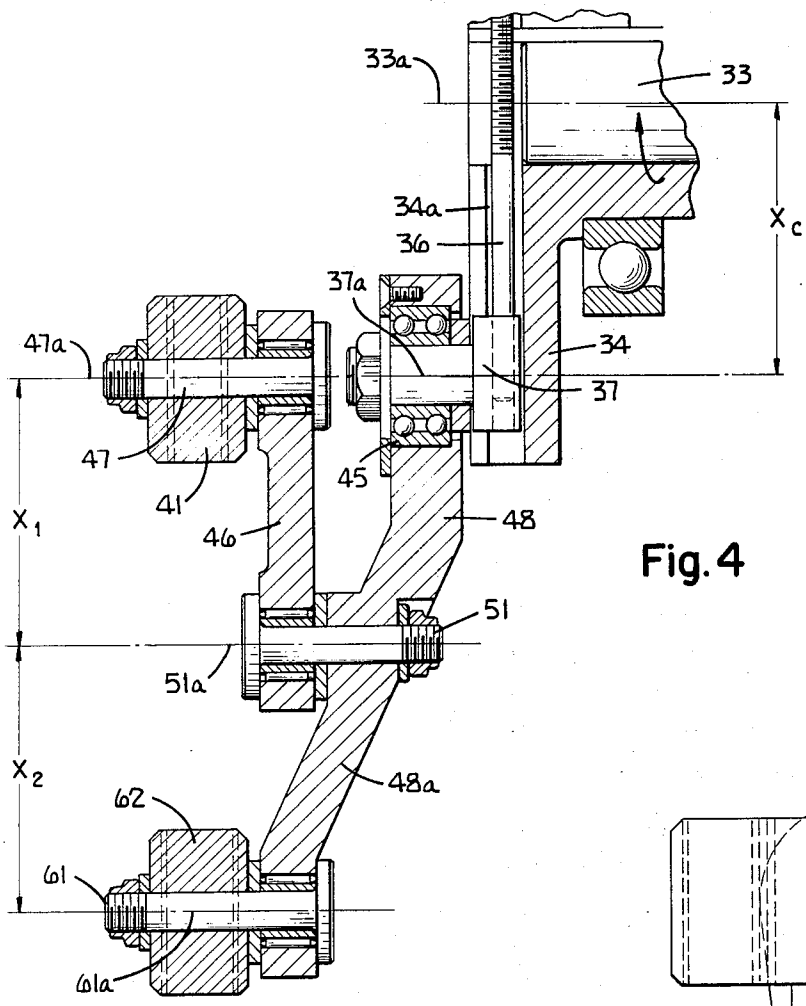

33a
33
34a
36
37a
34
37
47a
47
41
45
48
46
51
51a
48a
62
61
61a
X_c
X_1
X_2

Fig. 4

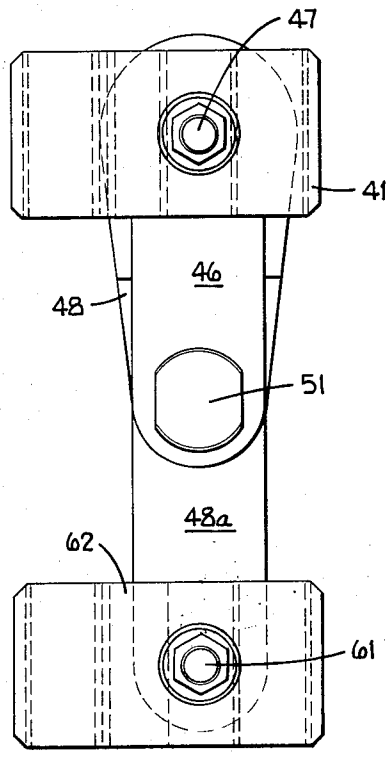

47
41
46
48
51
48a
62
61

Fig. 5

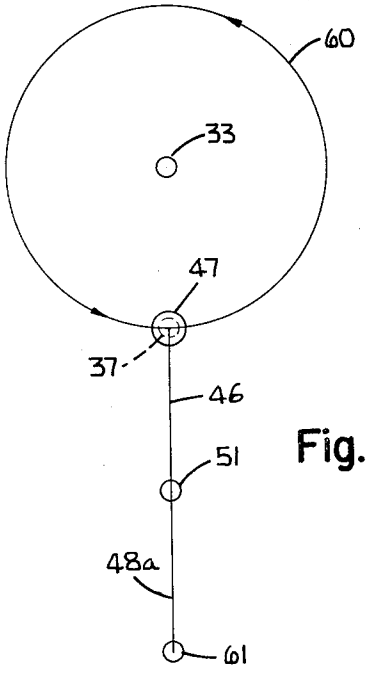


Fig. 6

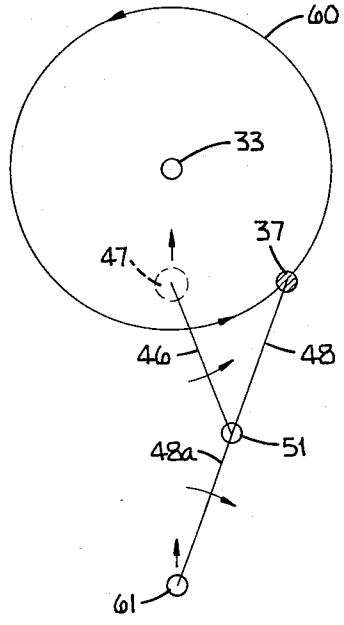


Fig. 7

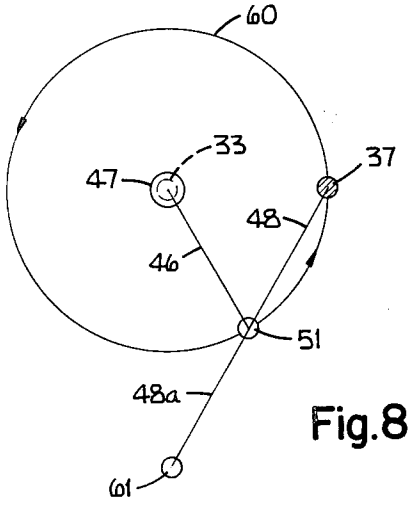


Fig. 8

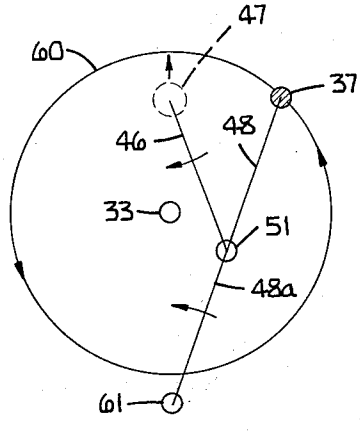


Fig. 9

MOTION CONVERSION APPARATUS

BACKGROUND OF THE INVENTION

This application is directed to apparatus which cooperates with that disclosed and claimed in my copending patent application Ser. No. 335,240, filed Feb. 23, 1973, now U.S. Pat. No. 3,785,212 and titled "Motion Altering Apparatus". In certain applications, such as high speed winding apparatus for manufacturing electrical stators, it is necessary to convert uniform rotation of a drive shaft into a repeating, rectilinear stroke of a winding head. The winding head is moved at high speed through a path formed of oscillating angular motion of the head and rectilinear displacement or stroke of the head in a plane normal to the plane of the angular motion. An example of such apparatus is disclosed in my U.S. Pat. No. 2,949,789.

Conventionally, a Scotch yoke drive is used to provide the rectilinear stroke for the winding head. Scotch yoke drives eliminate the irregularity of motion common to all ordinary crank drives. However, they have disadvantages for high speed stator winding operations. In a Scotch yoke drive the slot in the cross-head or slide in which the crankpin moves must, inherently, be as large as the stroke. To accommodate the desired slot length, for large stroke winding machines, the mass of the slide must be relatively large, and this gives vibration and wear problems in high speed operation. Attempts have been made to reduce the slide mass to a minimum for a given slot length, however, this results in physically weakening the slide resulting in premature failure of the apparatus. The drive apparatus disclosed in my above mentioned U.S. patent, although of improved performance over conventional Scotch yoke drives, does utilize moving members of considerable mass and slots in these members which are subject to wear.

The present invention is embodied in an improved winding head driving apparatus which provides the regular, symetrical motion of a Scotch yoke drive without the use of slots and which has relatively small mass for the maximum output stroke capability of the apparatus. Since no slots are used, wear is reduced to a minimum, and the apparatus is less costly to manufacture and assemble relative to comparably sized conventional constructions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of a prior art Scotch yoke drive apparatus.

FIG. **2** is a side view, partially in section, illustrating an embodiment of the present invention.

FIG. **3** is an end view, partially in section, of the structure shown in FIG. **2.**

FIG. **4** is an enlarged sectional view of the drive apparatus portion of the structure shown in FIG. **2.**

FIG. **5** is a front view of the structure shown in FIG. **4.**

FIG. **6** is a diagramatic view of the structure shown in FIG. **4.**

FIG. **7** is a diagramatic view showing the structure of FIG. **6** advanced through 45° of rotation of the crankshaft.

FIG. **8** is a diagramatic view showing the apparatus advanced through 90° of rotation of the crankshaft.

FIG. **9** is a diagramatic view illustrating the apparatus as positioned after rotation of the crankshaft through 135° from its position of FIG. **6.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring initially to FIG. **1,** there is shown a conventional Scotch yoke drive apparatus comprising a driving shaft **10** which, upon rotation moves a crankpin **11** through a circular path **12.** The crankpin carries a block **13** which has a sliding fit within a slot **14** in a cross-head or slide **16.** Extending rigidly from opposite sides of the cross-head is a shaft **17** which slides within bearings **18.** Movement of the crankpin **11** in its circular path by the drive shaft **10** will move the projection of the center of crankpin **11** on the horizontal diameter of the circular path **12** in harmonic motion along the longitudinal axis of the member **17.** This conventional Scotch yoke drive has, as previously pointed out the difficulty that the rectilinear stroke produced by the rotation of the drive shaft requires a slot in the cross-head at least equal to the length of the stroke.

The means for obtaining the same conversion of uniform rotation of the drive shaft into rectilinear harmonic motion of a cross-head or slide, embodying the present invention, is disclosed in FIGS. **2–8.** Referring initially to FIG. **2** there is shown a stator winding apparatus in which the vertical stroke of the winding head **21** is produced by the drive apparatus identified generally at **23.** The stator winding apparatus includes a generally rectangular housing **24** supported on members **26.** Extending from the upper portion of the housing is a winding head **21** which, as it is moved in a characteristic path lays wire in winding form upon an appropriately formed electrical stator (not shown). The winding head is supported on a splined shaft **27** which is oscillated about the vertical axis of the shaft **27** by means of the rack and pinion structure illustrated generally at **28.** The means for producing the oscillation of the winding head **21** in a horizontal plane, produced by the apparatus **28,** forms no part of the present invention and is claimed and described in detail in my aforementioned patent application. The apparatus of the present invention produces the required rectilinear vertical motion of the splined shaft whose lower extension is indicated at **27*a*** in FIG. **3.** Vertical motion of the shaft extension **27*a*** produces vertical motion of the winding head **21,** the winding head being supplied with wire **21*a*** through the interior of the hollow splined shaft **27** and shaft extension **27*a*** as will be evident from FIG. **3.**

As may be seen in FIGS. **2** and **3** a drive motor **31,** by means of a drive belt **32** (FIG. **3**) rotates, in the direction indicated, a drive shaft **33.** Carried on the end of the drive shaft **33,** and supported by suitable bearings is a generally disc-shaped member **34.** As may best be seen in FIG. **4,** the disc-shaped member **34** is provided with a diametrically extending slotted aperture **34*a***. A throw-adjusting screw **36** is threaded into a portion of the aperture **34** and is also threaded into an appropriately tapped aperture in a crank member **37.** From FIG. **4** it will be understood that rotation of the adjustment screw **36** from its upper end (not shown) will move the position of the crank member **37** along a diameter of the disc-shaped member **34,** the adjusting screw **36** thus providing a means for adjusting or varying the throw or offset of the crank member **37** with relation to the axis of rotation **33*a*** of the drive shaft **33.**

As shown in FIG. 4, the crank member 37 is adjusted to its maximum throw position. Referring again to FIGS. 2 and 3, the shaft 27*a* is rigidly secured to a cross-head or slide member 41 which is rigidly attached to the shaft 27*a*. Vertical, parallel guide rods or tracking elements 42 extend through appropriate apertures in the cross-head member 41, the rods 42 serving as guide means constraining the cross-head member to move vertically, that is, vertically along a diameter of the circular path followed by the crank member 37 as the drive shaft 33 rotates.

The means connecting the crank member 37 and the cross-head member 41 includes a linking member 46 (FIG. 4) which is pivotally joined by means of the pin 47 to the cross-head member 41. An arm 48 having an extending portion 48*a* (FIG. 4) is pivotally joined, by means of a suitable bearing 45 to the crank member 37. The arm 48 and the linking member 46 are pivotally joined by means of the pin 51. The axis of pivotal junction 51*a* of the linking member 46 and the arm 48 is offset equally from the pivotal axis of junction 47*a* of the linking member 46 to the cross-head member 41 and from the pivotal axis of junction 37*a* of the arm 48 to the crank member 37, this distance being indicated at x_1 in FIG. 4. The distance indicated at x_c in FIG. 4, that is, the distance between the axes 37*a* and 33*a* represents the throw of the crank member 37 and when the crank member 37 is adjusted to its maximum throw position, as shown in FIG. 4, the distance x_c equals the distance x_1. The distance x_c may, depending upon the position of adjustment of the crank member 37, be less than the distance x_1.

The extending end 48*a* of the arm 48 is pivotally joined, by means of the pin 61, to a guide member 62 which, as may best be seen in FIG. 3, is apertured to freely receive the guide rods 42. It will be understood that the drive member 62 is constrained by the guide rods 42 to move in a rectilinear path which is an extension of the vertical diameter of the circular path in which the crank member 37 is moved by the member 34 upon rotation of the drive shaft 33. The guide member 62 is not connected to, and moves independently of, the shaft portion 27*a*. The axis of pivotal juncture of the guide member or block 62 with the arm portion 48*a*, the axis being indicated at 61a in FIG. 4, is offset from the axis 51*a* by a distance indicated at x_2 in FIG. 4. The distance x_1 is equal to the distance x_2, that is, the separation of the axis 61*a* from the axis 51*a* is equal to the separation of the axis 47*a* from the axis 51*a*.

Operation of the motion converting apparatus will now be described with particular reference to, sequentially, FIGS. 6, 7, 8 and 9. In FIGS. 6–9 the apparatus shown in FIGS. 4 and 5 is indicated schematically, and the circular path in which the crank member 37 moves as the drive shaft 33 rotates uniformly is identified at 60. The linking member 46 is shown in FIG. 6 and, it will be understood, the arm 48 (as indicated by the position of the extension 48*a* of the arm) is aligned behind the member 46. The pin 61, it will be understood, is constrained to move vertically (as shown in FIG. 3) because of the cooperation of the guide member 62 with the guide rods 42. The cross-head member 41 (FIG. 4) and the pin 47 (FIG. 6) are constrained, by the guide rods 42, to move along a vertical diameter of the circular path 60. As shown in FIG. 6 the elements are at bottom dead center, the positions they occupy in FIGS. 2, 3, 4 and 5. As the drive shaft 33 uniformly rotates through 45° counterclockwise, the arm 48 will move to the position shown in FIG. 7, moving pin 47 (and the cross-head member 41 carried by it) upwardly to the position shown in FIG. 7. The pin 61 will be moved upwardly into its position shown in FIG. 7. It will be noted that the crank member 37 and the pin 47, although now not coincident, are on the same horizontal line.

As the drive shaft 33 moves through an additional 45° the elements will move from their position of FIG. 7 into their position of FIG. 8 in which the pin 47 (and the cross-head member carried by it) is moved upwardly along the vertical diameter of the circular path 60 into coincidence with the axis of drive shaft 33 and the center of the circular path 60. The crank member 37 will be moved to its position of FIG. 8 and pin 61 will have been advanced vertically upwardly. The pin 47 will have traversed one-half the vertical diameter of the circular path 60 and remains horizontally aligned with the crank member 37.

In FIG. 9, the drive shaft 33 has rotated an additional 45° beyond the position of FIG. 8. The pin 47 and the cross-head 41 carried by it will have moved vertically upwardly along a diameter of the circular path 60 to the position shown in FIG. 9 and the crank member 37 will have assumed a position horizontally aligned with the pin 47 and the pin 61 will continue its upward motion along an extension of the vertical diameter of the circular path 60. Further rotation of the drive shaft 33 counterclockwise, as viewed in FIG. 9, will move the pin 47 and the cross-head member 41 to its upper limit of motion along the vertical diameter of the path 60 and, in this upper dead center position, the pin 47 will overlie the crank member 37. Further rotation of the drive shaft 33 merely repeats the motions just described. It will be evident that the pin 47, and the cross-head member carried by it, move along the diameter of the circular path 60 always remaining aligned with the crank member 37 on a line which is normal to the circular path diameter along which the pin 47 travels. The pin 47 travels along this diameter as a projection of the crank member 37 on that diameter and thus pin 47, and the cross-head member 41 carried by it, move with simple harmonic motion as drive shaft 33 uniformly rotates. The block 62, carried by the pin 61, merely acts as a guide for the end of the arm 48 and moves up and down an extension of the vertical diameter of the circular path 60 but at a different velocity from that of the pin 47.

It will be noted that by shortening the throw of the crank member 37 by utilizing the adjusting member 36, the circular path 60 of the crank member 37 may be decreased and, under these conditions, the pin 47 and the cross-head member 41 carried by the pin will move, as the drive shaft 33 rotates, along a diameter of the reduced circular path of the crank member 37 and the stroke of the cross-head member will correspondingly be reduced. The motion of the cross-head fulfills the requirements for Scotch yoke motion, however, no slots or substantial mass members are necessary to achieve this motion. The structure is thus particularly adapted for use in providing the stroke motion of a winding head in a high speed stator winding apparatus as generally disclosed in FIGS. 2 and 3.

I claim:

1. Apparatus for converting uniform rotation of a drive shaft into rectilinear simple harmonic motion of a cross-head, said apparatus including: a crank member

(37) offset from the axis (33a) of the drive shaft (33) and driven thereby in a circular path (60), a cross-head member (41) and guide means (42) therefor constraining the cross-head member to move rectilinearly along a diameter of said circular path of the crank member, and means connecting said crank and cross-head members comprising a linking member (46) pivotally joined to said cross-head member (41) and an arm (48) pivotally joined to said crank member, said arm and linking member being pivotally joined to each other on an axis (51a) which is offset equally from the pivotal axis (47a) of the junction of said linking member to the cross-head member and from the pivotal axis (37a) of the junction of said arm to the crank member, the ratio of the offset (x_1) of the axis (51a) of pivotal junction of the arm and linking member to the offset (x_c) of said crank member from the drive shaft axis (33a) being adjustably variable.

2. Apparatus for converting uniform rotation of a drive shaft into rectilinear harmonic motion of a cross-head, said apparatus including: a crank member (37) offset from the axis (33a) of the drive shaft (33) and driven thereby in a circular path (60), a cross-head member (41) and guide means (42) therefor constraining the cross-head member to move rectilinearly along a diameter of said circular path of the crank member, and means connecting said crank and cross-head members comprising a linking member (46) pivotally joined to said cross-head member and an arm (48) pivotally joined to said crank member, said arm and linking member being pivotally joined to each other on an axis (51a) which is offset equally from the pivotal axis (47a) of the junction of said linking member to the cross-head member and from the pivotal axis (37a) of the junction of said arm to the crank member, said arm being pivotally joined to a guide block (62) on an axis (61a) offset from the axis (51a) of pivotal junction of said arm and linking member a distance equal to the offset of said axis (51a) of pivotal junction of the arm and linking member from the pivotal axis (47a) of the junction of said linking member to the cross-head member, said guide block being constrained by said guide means to move rectilinearly in a path aligned with the path of motion of said cross-head member.

3. Apparatus as claimed in claim 2 in which said guide means includes a rectilinear guide rod extending freely through apertures in both said cross-head member and in said guide block.

4. Apparatus as claimed in claim 2 in which the magnitude of the offset of said crank member from said axis of rotation of the drive shaft is adjustable to vary the diameter of the circular path in which said crank member moves.

5. Apparatus as claimed in claim 2 in which said cross-head member carries a stator winding head.

6. Apparatus for converting uniform rotation of a drive shaft into rectilinear harmonic motion of a cross-head, said apparatus including: a crank member offset from the axis of rotation of the drive shaft and driven thereby in a circular path, an arm pivotally joined to said crank member adjacent one of its ends, a guide member pivotally joined to the opposite end of said arm on an axis parallel to the axis of pivotal juncture of said crank member and said arm, and a tracking element for said guide member constraining said guide member to move rectilinearly in a path which is an extension of a diameter of said circular path of the crank member, a linking member pivotally joined to said arm intermediate its end, the axis of pivotal juncture of said arm and linking member being parallel to and midway between the axis of pivotal juncture of said crank member and arm and the axis of pivotal juncture of said guide member and arm, and a cross-head member constrained to move along said diameter of the crank member path, said cross-head member being pivotally joined to said linking member on an axis spaced from the axis of pivotal juncture of said linking member and arm a distance equal to the distance between said axis of pivotal juncture of said linking member and arm and said axis of pivotal juncture of said guide member and arm, whereby upon uniform rotation of said drive shaft said cross-head member moves in rectilinear harmonic motion along said circular path diameter.

7. Apparatus as claimed in claim 6 in which the offset distance of said crank member from the axis of rotation of the drive shaft is adjustable.

8. Apparatus as claimed in claim 6 in which said cross-head member carries a stator winding head.

* * * * *