June 1, 1937. F. W. SEYBOLD 2,082,183

BED MOTION

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FIG. 1.

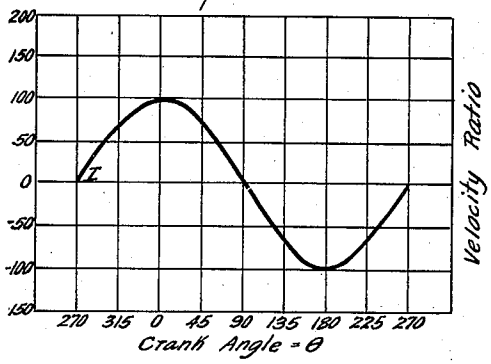


FIG. 2.

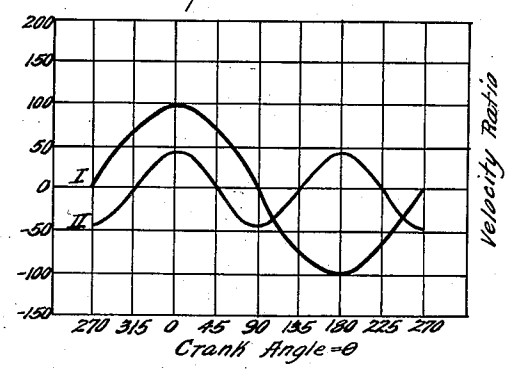


FIG. 3.

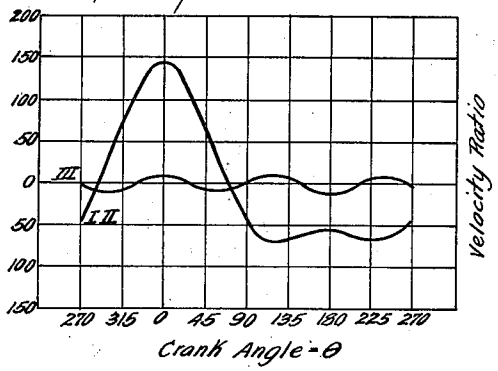


FIG. 4.

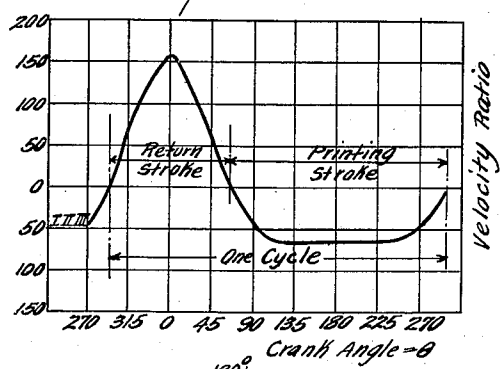


FIG. 5.

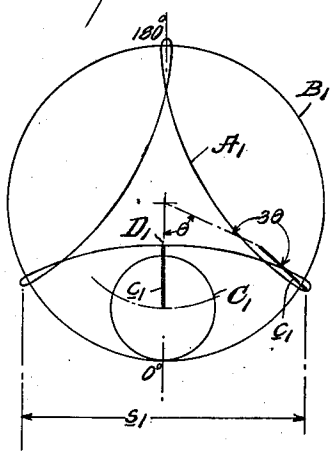
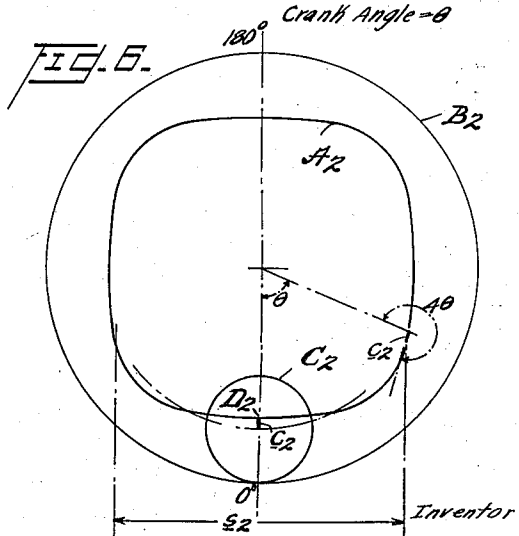


FIG. 6.



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BED MOTION

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FIG. 7.

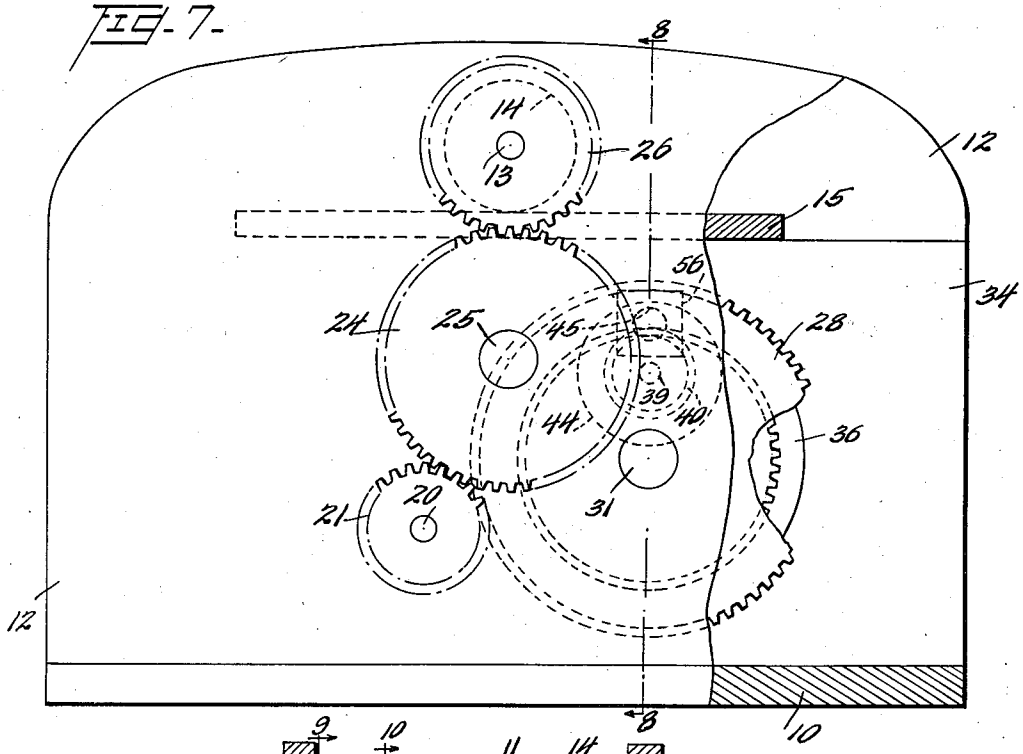
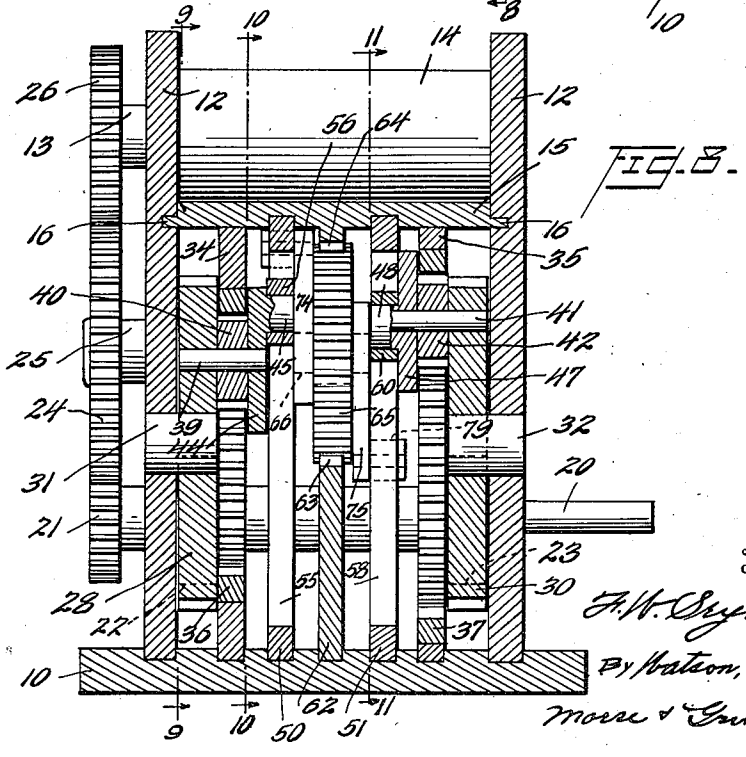


FIG. 8.



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BED MOTION

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FIG. 9.

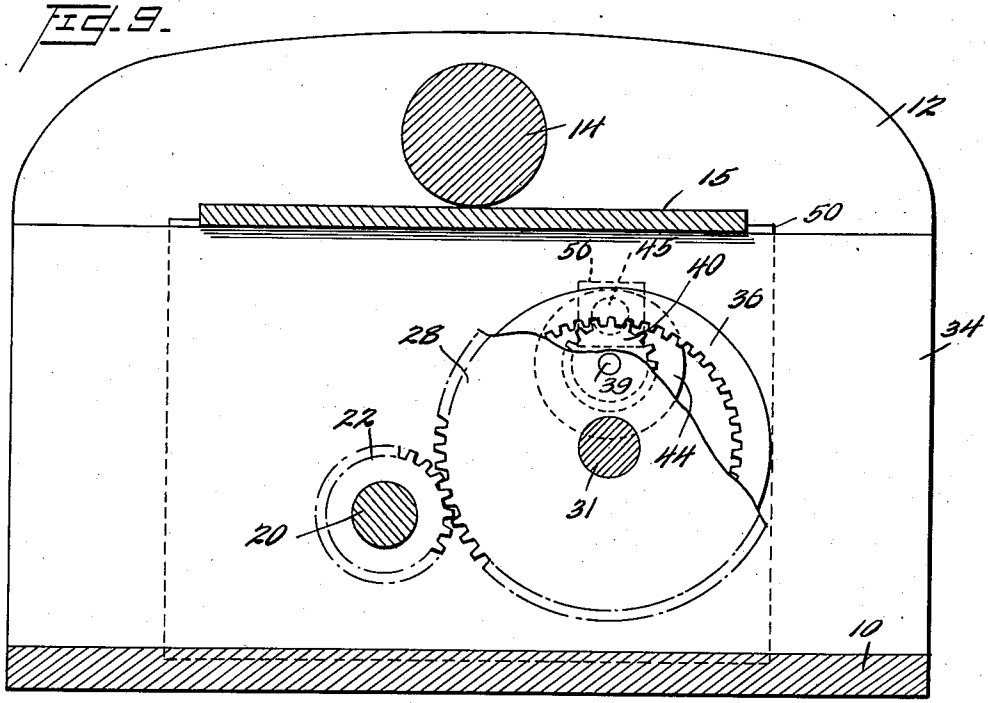


FIG. 10.

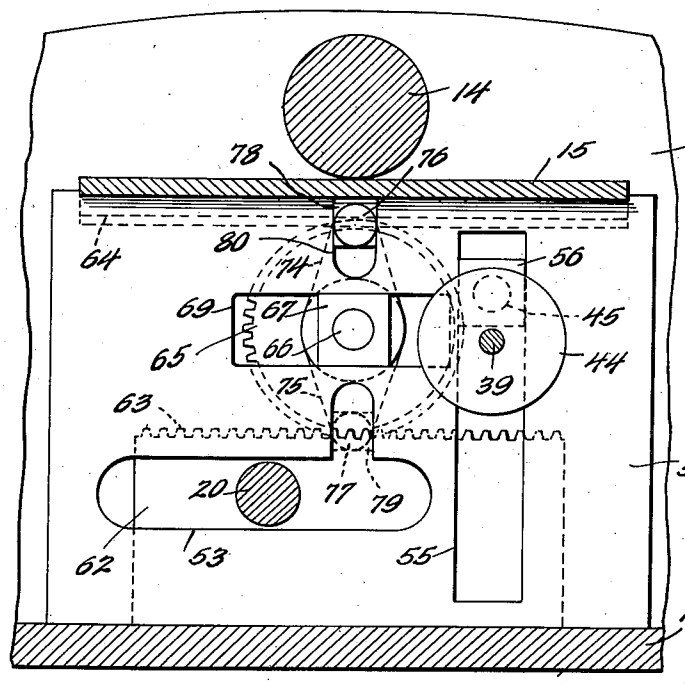
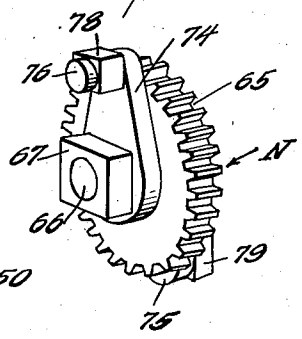


FIG. 14.



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BED MOTION

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FIG. 11.

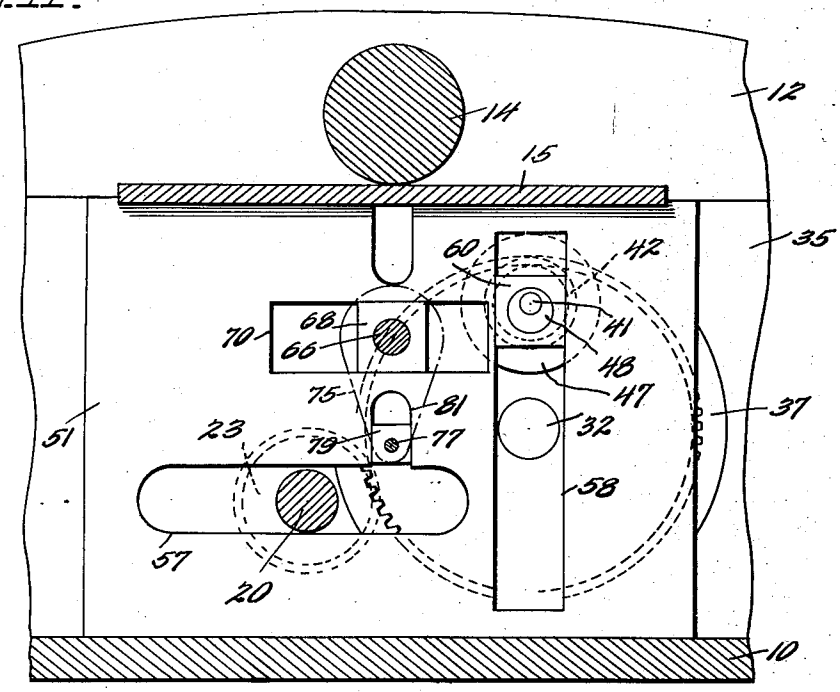


FIG. 12.

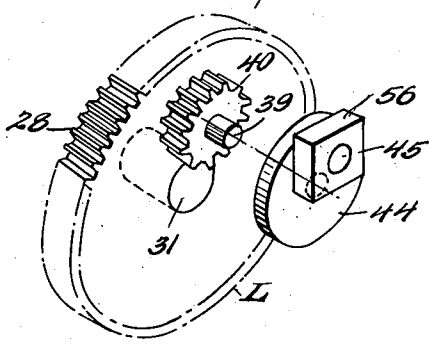
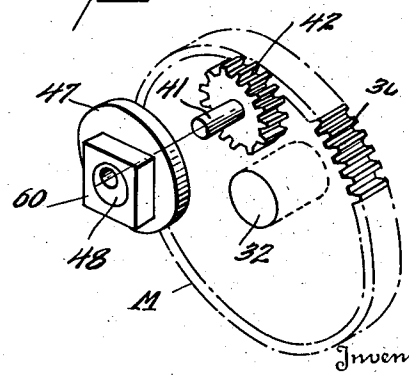


FIG. 13.



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Patented June 1, 1937 2,082,183

UNITED STATES PATENT OFFICE

2,082,183

BED MOTION

Frederick W. Seybold, Westfield, N. J., assignor, by mesne assignments, to American Type Founders Company, Elizabeth, N. J., a corporation of New Jersey

Application September 21, 1935, Serial No. 41,607

25 Claims. (Cl. 74—27)

This invention relates to reciprocating bed motions or the like and more particularly to mechanism of this character especially adapted to be embodied in printing presses of the flat bed and cylinder type.

It is the principal object of this invention to provide a novel and improved reciprocating bed motion by means of which a bed may be oscillated in a complete cycle, the greater portion of the movement of the bed in one direction being at substantially constant speed, while in the other direction the bed has a continually varying velocity.

A further object of the invention is to provide a bed motion for this purpose in which all of the bed driving gearing remains constantly in mesh, and in which no cams, gates, latches, locks or any intermittently operating reversing gear is employed. To attain this object, my invention in its preferred embodiment contemplates the provision of a plurality of differently proportioned trains of mechanism including cranks, gears and sliding cross-heads which may be driven from a common source of power and which are adapted to be continuously, positively, and operatively connected with said bed through means which is adapted to compound the movements imparted by said trains and to transmit the resultant of these movements to the bed.

Another object of the present invention is the provision of a bed motion of this type, the stroke of which is longer than in the case of the standard 3:1 bed motion, thus affording increased form roller coverage for a given cylinder diameter.

Still another object is to provide bed driving mechanism composed of parts which can be readily produced on standard machine tools at low cost.

Other objects and features of novelty will be apparent from the following specification when read in connection with the accompanying drawings in which one embodiment of my invention is illustrated by way of example. The drawings also include figures representing graphically the development of the theories underlying my invention.

In the drawings:

Figures 1–4 inclusive depict graphs illustrating the development of the desired velocity ratio curve of the reciprocating bed;

Figures 5 and 6 are diagrams showing the paths or orbits of certain crank pins which impart the two separate motions which are components of the resultant motion finally imparted to the bed;

Figure 7 is a view in side elevation, with certain parts broken away, of an illustrative model of a printing press of the bed and cylinder type to which the principles of my invention have been applied;

Figure 8 is a view of the press in transverse vertical section taken on line 8—8 of Figure 7;

Figure 9 is a longitudinal vertical sectional view taken on line 9—9 of Figure 8;

Figure 10 is a fragmentary longitudinal vertical sectional view taken on line 10—10 of Figure 8;

Figure 11 is a similar view taken on line 11—11 of Figure 8;

Figures 12 and 13 are exploded perspective views of the main portions of the two trains of mechanism which develop the resolved motions; and

Figure 14 is a view in perspective of the travelling gear and its crank arms by means of which the two component motions are compounded and imparted to the reciprocating bed.

In the printing art, it has long been recognized as desirable, during the printing period of a press of the kind illustrated, when the reciprocating type bed and the rotary impression cylinder are in rolling contact, that these members be moving at a uniform linear velocity so as to prevent marring the impression, and insure proper registry. Numerous expedients have been proposed to attain this condition of uniform speed, but these have for the most part depended upon a plurality of different driving mechanisms for alternately driving the bed during different portions of its printing and return strokes and also for reversing the bed at the ends of the strokes; or they have employed cam grooves or the like to give a substantially constant velocity to the type bed during printing.

According to the present invention, however, the train of mechanism comprising the driving transmission of the press is always in gear and exerting a positive force upon the bed, while at the same time elaborate cam and clutch mechanisms have been eliminated; it being possible to economically manufacture all parts comprising the bed motion on standard machine tools.

A reciprocating bed actuated by a sliding crosshead or yoke driven by a simple crank arm, as in the case of the familiar Scotch yoke, would have a linear velocity which varies at every point, attaining a maximum at mid-stroke and amounting to zero at the points of reversal at the ends of the strokes. This movement is one of pure simple harmonic motion, the general velocity equation of which $V_b=\omega R \cos \theta$, where θ is the angle the crank makes with the horizontal. The velocity ratio curve representing the relation of the velocity of the bed and the constant linear velocity of the crank pin is, of course, the familiar sinusoid illustrated in Figure 1 of the drawings, and is expressed in this case by the equation $y=100 \cos \theta$.

As has been explained, the problem is to flatten one of the loops of this velocity ratio curve

so as to produce a constant speed during the period when printing takes place. The mechanical attainment of this desired result by means of my invention can be briefly explained as follows. The flattening of the loop of the simple harmonic velocity ratio curve which represents the printing stroke can be accomplished by the super-position of certain other simple harmonic motions upon the first motion represented by the curve in Figure 1. The velocity ratio equation representing these combined motions is then integrated so that the displacement equation of the bed movement may be obtained. This displacement equation is then split into two separate equations which are recognizable as representing the displacement equations of hypotrochoids. A hypotrochoid being the path of a point on the radius or radius produced of a circle rolling inside of a fixed circle, these orbits may be obtained by means of a crank fastened to a pinion which meshes with and rolls within a fixed internal gear, the pinion rotating on an arm which is preferably driven at a constant speed. In developing the resultant movement, each of the cranks is made to oscillate a sliding cross-head by means of a pin and slot connection, and the motions of these cross-heads, which are the projections of the hypotrochoidal movements of the crank pin on a horizontal line, may be added or compounded mechanically by means of a travelling gear, the axis of which is connected with the cross-heads by means of rigid crank arms having pin and slot connections therewith. The travelling gear, of course, is adapted to roll on a fixed rack and to mesh with a rack carried by the reciprocating bed, thus doubling the motion of the gear as applied to the bed. The proportionate dimensions of the cranks and gears comprising the transmission thus described, in order to attain the constant velocity phase of the bed cycle, may be obtained from the equations. The development of these constructions and their relative dimensions will now be set forth in detail.

In the graphs comprising Figures 1–4 inclusive, the crank angles are the abscissas and the velocity ratios in either direction are the ordinates and are graduated in plus and minus quantities upwardly and downwardly from the zero line, which, of course, indicates the point of change of direction of movement. In Figure 1, the simple harmonic curve I is represented by the equation $y_1=100 \cos \theta$. In Figure 2 there is shown a second simple harmonic curve II represented by the equation $y_2=a \cos 2\theta$. If these equations I and II be combined or added there is obtained the equation $y_{1,2}=100 \cos \theta+a \cos 2\theta$ represented by the curve I, II in Figure 3. It will be noted that the velocity ratio curve of this combined harmonic motion shows a sharper loop at the beginning and a somewhat flatter portion between the 120° and 240° points of the cycle.

A third simple harmonic curve III is also shown in Figure 3 and may be expressed by the equation $y_3=b \cos 3\theta$. When this third curve is superposed upon the curve I, II the resultant curve is as shown in Figure 4 in which the portion from 120° to 240° is for all practical purposes a straight line. The portion of the cycle containing this flat section or constant velocity ratio may be employed on the printing stroke and the continuously variable velocity ratio section represented by the first loop of the curve I, II, III may be employed on the return stroke.

The resulting equation represented by the curve I, II, III in Figure 4 is

$$y_{1,2,3}=100 \cos \theta+a \cos 2\theta+b \cos 3\theta$$

in which the values a and b have been selected so that for values of θ between 120° and 240° the velocity $y_{1,2,3}$ will remain constant and equal to approximately

$$100\left(\frac{2}{\pi}\right) \text{ or } 63.6.$$

These values of a and b have been determined as being 46.5 and 10 respectively in order to give an approximately constant velocity between 120° and 240°. The average value of $y_{1,2,3}$ is 63.47. Substituting these values for a and b, the equation for the desired velocity ratio curve shown in Figure 4 becomes

$$y_{1,2,3}=100 \cos \theta+46.5 \cos 2\theta+10 \cos 3\theta \quad (1)$$

Now in order to determine the ratios of the physical dimensions of the parts that will produce a bed motion having the properties of the resultant velocity ratio equation, the next step is to integrate the velocity ratio equation for $y_{1,2,3}$ to obtain the displacement equation giving the value of the linear displacement $s_{1,2,3}$. Thus

$$s_{1,2,3}=\int 100 \cos \theta+46.5 \cos 2\theta+10 \cos 3\theta \quad (2)$$

$$s_{1,2,3}=100 \sin \theta+23.25 \sin 2\theta+\frac{10}{3} \sin 3\theta \quad (3)$$

In order to reduce the size of the cranks and gears embodied in the bed motion so as to make the device practical for printing presses and the like and still obtain a relatively long bed stroke, recourse is had to the well known multiplying or travelling gear. Therefore, the displacement of the latter is one-half that of the reciprocating bed, making the equation for the displacement of the travelling gear

$$s_t=\frac{s_{1,2,3}}{2}=50 \sin \theta+11.625 \sin 2\theta+\frac{5}{3} \sin 3\theta \quad (4)$$

The ends of the strokes of the bed, of course, occur at the points of reversal when the velocity is zero, and the values of θ obtained by solving Equation (1), with $y_{1,2,3}$ equaling zero, are 66° 1′ and 293° 59′. In accordance with these values the curve in Figure 4 is seen to cross the zero line at points representing these angles in the abscissas of the graph. The displacement equation for $s_{1,2,3}$ can be broken up into two equations, namely:

$$s_1=f \sin \theta+23.25 \sin 2\theta \quad (5)$$

and

$$s^2=g \sin \theta+\frac{10}{3} \sin 3\theta \quad (6)$$

On these assumptions, the following two equations must be true:

$$f+g=100 \quad (7)$$

$$s_1+s_2=s_{1,2,3} \quad (8)$$

The partial Equations (5) and (6) will be recognized as being of the general form:—

$$s=ck \sin \theta+c \sin (m-1)\theta \quad (9)$$

this equation expressing the ordinate of a hypotrochoid which, as has been already stated, is the path generated by a crank pin fastened to a pinion which meshes with and rolls in a fixed internal gear, the pinion rotating on an arm which for these purposes is driven at a constant speed.

In Equation (9),

s=the displacement of the cross-head of one of the transmissions,

c=the length of the crank on the pinion,

ck=the length of the crank arm on which the pinion rotates, i. e., the distance between centers of the pinion and internal gear,

m=the gear ratio between the internal gear and the pinion,

θ=the angle of rotation of the pinion driving crank arm.

In order that each cross-head shall have travelled approximately the same distance when θ=66° 1′ or 293° 59′ the constants f and g are determined from Equations (5) and (6) as follows:—

$$f \sin 66° 1' + 23.25 \sin 132° 2' = g \sin 66° 1' + 10/3 \sin 198° 3' \cdot \quad (10)$$

$$f+g=100 \quad (7)$$

$$.91366f + 23.25 \times .74275 = .91366g + 10/3(-.30985) \quad (10a)$$

$$.91366f + .91366g = 91.366 \quad (7a)$$

$$.91366f - .91366g = -18.302 \quad (10b)$$

$$1.82732f = 73.064 \quad (11)$$

$$f = \frac{73.064}{1.82732} = 40 \quad (12)$$

$$\text{From (7) } g = 100 - f = 100 - 40 = 60 \quad (13)$$

Substituting the values for f and g in Equations (5) and (6) respectively,

$$s_1 = 40 \sin \theta + 23.25 \sin 2\theta \quad (14)$$

and

$$s_2 = 60 \sin \theta + 10/3 \sin 3\theta \quad (15)$$

Adding (14) and (15) gives

$$s_{1,2,3} = 100 \sin \theta + 23.25 \sin 2\theta + 10/3 \sin 3\theta \quad (3)$$

Equation (9) indicates that the gear ratio m for Equation (5) must be 3, and for Equation (6) the value of m equals 4, in order to give sin 2θ and 3θ respectively.

From Equations (4) and (8), we find that

$$s_t \text{ (the displacement of the travelling gear)} = \frac{s_1 + s_2}{2}$$

Therefore, the length of the crank which drives one of the cross-heads is

$$\frac{23.25}{40} = .58125$$

times the center distance between the pinion and the internal gear within which it rolls. In the other transmission the length of the crank which drives the cross-head is

$$\frac{10/3}{60} = .0555$$

times the center distance between this pinion and its associated internal gear.

The actual sizes of the internal gears and the pinions, and of the other elements comprising the transmission depend of course on the size of the sheet to be printed and form roller coverage that is desired, which determines the length of the press bed stroke.

With the hypotrochoid equations developed above and the values which have been obtained to fit the requirements for producing the bed motion velocity ratio curve illustrated in Figure 4, the actual orbits of the crank pins which describe the hypotrochoidal paths may be reproduced graphically as in Figures 5 and 6. The first transmission with its crank ratio of .58, as developed in the preceding paragraphs, and its gear ratio of 3:1, will yield a motion whose orbit is represented by the curtate hypotrochoid A_1 in Figure 5. The circle B_1 represents the internal gear and the circle C_1 represents the pinion whose crank arm is designated c_1. The horizontal displacement of the crank pin D_1 in this diagram is represented by s_1, the angle made by the crank c_1 with the center distance between the pinion and the internal gear being shown as 3θ.

The diagram of the motion developed by the second transmission train is represented in Figure 6 in which the path of movement of the crank pin D_2 is a prolate hypotrochoid shown at A_2, the internal gear is indicated at B_2, the pinion at C_2 and the crank arm at c_2, the length of this last element being relatively small, the horizontal displacement of the crank pin being indicated at s_2.

The actual mechanical details of the particular motions which have been referred to in connection with the developments just described, will now be referred to in connection with the appropriate constructional figures of the drawings.

For the sake of clearness, there has been illustrated in the drawings a model of a press embodying the principles of the invention in which numerous details which are not essential to the illustration of the development of the bed motion are omitted. The press is of the flat bed, two revolution, constant speed cylinder type and is provided with a base **10** upon which are mounted the side frames **12** which are provided with suitable bearings for the axle **13** of the impression cylinder **14**. The reciprocating type bed is illustrated at **15** and is provided in the illustrative model with suitable guides **16** in the side frames **12**. It will be realized, of course, that in a practical embodiment of the invention in an actual press the bed may be provided with the usual roller tracks and other refinements and accessories. A common drive shaft **20** having suitable bearings in the side frames is employed to drive both the bed and the impression cylinder and is itself adapted to be driven by a suitable motor. Upon the drive shaft are secured the pinions **21**, **22** and **23**. The pinion **21** mounted on an end of the drive shaft **20** exteriorly of one of the side frames **12** meshes with the gear **24** which is mounted upon the stud **25** and in turn meshes with the impression cylinder gear **26**. The ratios of this train of gearing are selected so as to give a constant angular velocity to the impression cylinder corresponding to the linear velocity of the bed during the printing stroke. Of course, suitable means are provided for raising the impression cylinder out of contact with the bed during non-printing periods.

The pinions **22** and **23** carried by the drive shaft **20** serve to effect the movements of the two transmission trains, which may for convenience be given the general designations L and M, and which develop the component motions which are combined and applied to the bed. The pinions **22** and **23** mesh with the large gears **28** and **30** which turn on the stub shafts **31** and **32** respectively, each making one revolution per cycle. Intermediate the side frames **12** there are provided longitudinally extending bed supporting frames **34** and **35** which are cut out to receive the stationary internal gears **36** and **37** respectively. The pitch circles of these internal gears **36** and **37** correspond with the circles B_1 and B_2 on the diagrams in Figures 5 and 6. The large gear **28** of the train L is provided with a shaft **39**

upon which a pinion 40 is rotatably mounted. The pinion 40 is adapted to mesh with the internal gear 36 and roll within the same, this pinion being indicated diagrammatically in Figure 5 at C_1. As deduced mathematically, the gear ratio of the internal gear 36 and the pinion 40 is 3:1. In the transmission train M a similar shaft 41 is carried by the gear 30 and provides an axle for the pinion 42 which rolls in mesh with the internal gear 37, the ratio between the two being 4:1. The pinion 42 is represented in Figure 6 by the circle C_2. A crank disc 44 is rigidly secured to the pinion 40 and is provided with a crank pin 45 and the pinion 42 carries the crank disc 47 which is provided with the crank pin 48. The cranks 44 and 47 are represented in the diagrams in Figures 5 and 6 by the lines c_1 and c_2 and the crank pins 45 and 48 are indicated at the points D_1 and D_2. By means of the trains of gearing which have just been described, the crank pins 45 and 48 are made to describe the hypotrochoidal orbits indicated at A_1 and A_2 in Figures 5 and 6.

Longitudinally slidable within grooves formed in the base 10 and the type bed 15 are the slotted cross-heads 50 and 51. These cross-heads or slides are shown very clearly in elevation in Figures 10 and 11 respectively of the drawings. The cross-head 50 is provided with a horizontally extending slot 53 which permits the passage of the drive shaft 20 without hindrance during the sliding movements of the cross-head. A vertical slot 55 is also cut in the cross-head 50 within which the squared block 56 is adapted to reciprocate, this block being rotatably carried by the crank pin 45 during its complex movement. It will thus be seen that the cross-head 50 is reciprocated longitudinally through a cycle of movement which is the projection of the hypotrochoidal movement of the crank pin 45 upon a horizontal line parallel with the bed 15. Similarly the cross-head 51 is provided with a clearance slot 57 for the drive shaft 20 and a vertical slot 58 for receiving the block 60 carried by the crank pin 48 of the transmission M, and the motion of the slide 51 is the projection of the hypotrochoidal movement of the crank pin 48 upon the horizontal.

In order to compound these projected hypotrochoidal movements developed by the transmission trains L and M and impressed on the slides 50 and 51, the following mechanism is provided, which is designated generally by the reference character N. (See particularly Figure 14.) Upon a centrally located support 62 there is provided a stationary rack 63. Upon the underside of the bed 15 there is provided a bed driving rack 64. Arranged so as to roll upon the stationary rack 63 is the travelling gear 65 which also meshes with the bed rack 64, thus multiplying its longitudinal movement as applied to the bed. The travelling gear 65 is provided with an axle 66 upon which it is rotatably mounted and which carries at its respective ends the blocks 67 and 68 which are respectively adapted to slide in the horizontal slots 69 and 70 of the slides 50 and 51. Rigidly secured to the axle 66 are the oppositely extending crank arms 74 and 75 having crank pins 76 and 77 respectively upon which are rotatably carried blocks 78 and 79. The block 78 is guided within the vertical slot 80 formed in the cross-head 50 and the block 79 within the slot 81 formed in the cross-head 51. It will thus be seen that the complex reciprocating movements of each of the cross-heads 50 and 51 are transmitted through their respective crank arms 74 and 75 to the axle of the travelling gear 65 and are thus compounded and applied through the gear 65 and the racks 63 and 64 to the bed.

It will be readily seen from the foregoing descriptions that there is provided by this invention a reciprocating bed movement which may be driven from a constantly rotating source such as the drive shaft 20 and transmission mechanism interposed between this source of power and the bed which comprises the trains L and M each of which develops a motion which corresponds to the partial Equations (5) and (6) set forth in the earlier portion of the present specification, and which also comprises the motion compounding mechanism N which receives the two component motions and combines them to obtain a motion, the displacement equation of which is Equation (3) as set forth above. This motion is imparted to the bed by the travelling gear and the constant velocity requirements of the printing stroke thereof are satisfied in accordance with the graph in Figure 4 of the drawings.

It might be observed also that in this construction the length of the bed stroke is 3.390 times the diameter of the impression cylinder as compared to the ratio of 2.761 obtained with a conventional 3:1 bed movement. The present embodiment, as already pointed out, is also distinguished by the feature of continuous gearing engagement and employs no auxiliary driving mechanisms, locks, gates, cams or latches.

The invention may be embodied in bed motions which differ somewhat insofar as the design and arrangement of their functioning parts are concerned, but each such embodiment includes at least two operating parts or portions thereof which are caused to move along cyclic paths, which paths are dissimilar in character, while maintaining constant phase relationship therebetween, and which comprise portions of the bed driving means. These parts are designated "driving elements" in claims appended hereto, and where it is stated that the elements move without "retracement" it is meant that they move continuously in one direction along their respective closed orbits and never retrace their paths during any single cycle of movement.

It will be further understood that various changes and modifications may be made in the embodiment illustrated more or less diagrammatically in the drawings, and described herein, without departing from the scope of the invention as defined by the following claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A bed movement of the type in which the bed during its working and return stroke is reciprocated in a plane, comprising the combination with the bed and means for supporting the same for planar movement, of a plurality of movable driving elements, means for moving said elements respectively, without retracement along dissimilar cyclic paths while maintaining constant phase relationship therebetween, and means maintaining a constant operative connection between said elements and the bed, said means receiving motion from both of said elements and transmitting to the bed a motion which is the resultant of the motions of said elements, whereby the bed is caused to move at substantially constant speed during the major portion of its movement in one direction.

2. A bed movement of the type in which the bed during its working and return stroke is re-

ciprocated in its own plane, comprising the combination with the bed and means for supporting the same for planar movement, of two movable driving elements, means for moving said elements respectively, without retracement along dissimilar cyclic paths while maintaining constant phase relationship therebetween, said paths lying in parallel planes which are normal to the plane of said bed, and means maintaining a constant operative connection between said elements and the bed, said means receiving motion from both of said elements and transmitting to the bed a motion which is the resultant of the motions of said elements, whereby the bed is caused to move at substantially constant speed during the major portion of its movement in one direction.

3. A bed movement of the type in which the bed during its working and return stroke is reciprocated in a plane, comprising the combination with the bed and means for supporting the same for planar movement, of a plurality of movable driving elements, means for moving said elements respectively, without retracement along dissimilar cyclic paths while maintaining constant phase relationship therebetween, and means maintaining a constant operative connection between said elements and the bed, said means receiving motion from both of said elements and transmitting to the bed a motion which is the resultant of the motions of said elements, whereby the bed is caused to move at substantially constant speed during the major portion of its movement in one direction, said last named means comprising a plurality of sliding crossheads, each of which is respectively driven by one of said driving elements, and means for operatively connecting said crossheads to said bed.

4. A bed movement of the type in which the bed during its working and return stroke is reciprocated in a plane, comprising the combination with the bed and means for supporting the same for planar movement, of a plurality of movable driving elements, means for moving said elements respectively, without retracement along dissimilar cyclic paths while maintaining constant phase relationship therebetween, and means maintaining a constant operative connection between said elements and the bed, said means receiving motion from both of said elements and transmitting to the bed a motion which is the resultant of the motions of said elements, whereby the bed is caused to move at substantially constant speed during the major portion of its movement in one direction, said last named means comprising a plurality of sliding crossheads, each of which is respectively driven by one of said driving elements, and a travelling gear driven by both of said sliding crossheads and meshing with a rack on said bed.

5. A bed movement of the type in which the bed during its working and return stroke is reciprocated in a plane, comprising the combination with the bed and means for supporting the same for planar movement, of a plurality of movable driving elements, means for moving said elements respectively, without retracement along dissimilar cyclic paths while maintaining constant phase relationship therebetween, and means maintaining a constant operative connection between said elements and the bed, said means receiving motion from both of said elements and transmitting to the bed a motion which is the resultant of the motions of said elements, whereby the bed is caused to move at substantially constant speed during the major portion of its movement in one direction, said last named means comprising a common member guided for reciprocation in the same direction as that of said bed, driving connections between said elements and said member, and means for operatively connecting said member to said bed.

6. A bed movement of the type in which the bed during its working and return stroke is reciprocated in a plane, comprising the combination with the bed and means for supporting the same for planar movement, of a plurality of movable driving elements, means for moving said elements respectively, without retracement along dissimilar cyclic paths while maintaining constant phase relationship therebetween, and means maintaining a constant operative connection between said elements and the bed, said means receiving motion from both of said elements and transmitting to the bed a motion which is the resultant of the motions of said elements, whereby the bed is caused to move at substantially constant speed during the major portion of its movement in one direction, said last named means comprising a common member tiltable about a center of rotation which is guided for reciprocation in the same direction as that of said bed, connections between said elements and points on said member spaced from said center of rotation, and means for operatively connecting said member to said bed.

7. A bed movement of the type in which the bed during its working and return stroke is reciprocated in a plane, comprising the combination with the bed and means for supporting the same for planar movement, of a plurality of movable driving elements, means for moving said elements respectively, without retracement along dissimilar cyclic paths while maintaining constant phase relationship therebetween, and means maintaining a constant operative connection between said elements and the bed, said means receiving motion from both of said elements and transmitting to the bed a motion which is the resultant of the motions of said elements, whereby the bed is caused to move at substantially constant speed during the major portion of its movement in one direction, said last named means comprising a common member which comprises a lever arm having an axle thereon, connections between said elements and spaced points on said lever arm, a travelling gear rotatably mounted on said axle and meshing with a rack on said bed.

8. A bed movement of the type in which the bed during its working and return stroke is reciprocated in a plane, comprising the combination with the bed and means for supporting the same for planar movement, of a plurality of movable driving elements, means for moving said elements respectively, without retracement along dissimilar cyclic paths while maintaining constant phase relationship therebetween, and means maintaining a constant operative connection between said elements and the bed, said means receiving motion from both of said elements and transmitting to the bed a motion which is the resultant of the motion of said elements, whereby the bed is caused to move at substantially constant speed during the major portion of its movement in one direction, said last named means comprising a stationary rack, a rack on said bed, a travelling gear adapted to roll on said stationary rack and mesh with said bed rack, and means for operatively connecting each of said driving elements with said gear.

9. A bed movement of the type in which the bed during its working and return stroke is re-

ciprocated in a plane, comprising the combination with the bed and means for supporting the same for planar movement, of a plurality of movable driving elements, means for moving said elements respectively, without retracement along dissimilar cyclic paths while maintaining constant phase relationship therebetween, each of said paths being hypotrochoids, and means maintaining a constant operative connection between said elements and the bed, said means receiving motion from both of said elements and transmitting to the bed a motion which is the resultant of the motions of said elements, whereby the bed is caused to move at substantially constant speed during the major portion of its movement in one direction.

10. A bed movement of the type in which the bed during its working and return stroke is reciprocated in a plane, comprising the combination with the bed and means for supporting the same for planar movement, of a plurality of movable driving elements, means for moving said elements respectively, without retracement along dissimilar cyclic paths while maintaining constant phase relationship therebetween, one of said paths being a prolate hypotrochoid and the other a curtate hyprotrochoid, and means maintaining a constant operative connection between said elements and the bed, said means receiving motion from both of said elements and transmitting to the bed a motion which is the resultant of the motions of said elements, whereby the bed is caused to move at substantially constant speed during the major portion of its movement in one direction.

11. A bed movement as set forth in claim 1, in which the resultant movement of the bed may be represented by the equation: $y=100 \cos \theta+46.5 \cos 2\theta+10 \cos 3\theta$, where y=the ratio of the velocity of the bed to the velocity of the constantly rotatably driving element, and θ=the angle of movement of said element.

12. A bed movement as set forth in claim 1, in which the resultant movement of the bed is compounded of three simple harmonic motions, said motions being described respectively by the following sinusoidal equations: $y_1=100 \cos \theta$; $y_2=46.5 \cos 2\theta$; and $y_3=10 \cos 3\theta$.

13. A reciprocating bed movement comprising a rectilinearly reciprocating bed, a rack on said bed, a stationary rack, a travelling gear adapted to roll on said last named rack and mesh with said bed rack, a plurality of sliding cross-heads operatively connected with said gear, and a separate train of gearing operatively connected with each of said cross-heads and adapted to impart motions to said cross-heads which are compounded and the resultant motion imparted to said bed through said gear.

14. A reciprocating bed movement comprising a rectilinearly reciprocating bed, a rack on said bed, a stationary rack, a travelling gear adapted to roll on said last named rack and mesh with said bed rack, a pair of sliding cross-heads, a lever carrying an axle for said travelling gear, and projecting studs at spaced points thereon, each of said studs being slidably received in a slot in one of said cross-heads and means for driving each of said cross-heads.

15. A reciprocating bed movement comprising a rectilinearly reciprocating bed, a rack on said bed, a stationary rack, a travelling gear adapted to roll on said last named rack and mesh with said bed rack, a pair of sliding cross-heads, a lever carrying an axle for said travelling gear and projecting studs at spaced points thereon, each of said studs being slidably received in a slot in one of said cross-heads, and separate means for imparting different movements to each of said cross-heads.

16. A reciprocating bed movement comprising a rectilinearly reciprocating bed, a rack on said bed, a stationary rack, a travelling gear adapted to roll on said last named rack and mesh with said bed rack, a pair of sliding cross-heads, a lever carrying an axle for said travelling gear, and projecting studs at spaced points thereon, each of said studs being slidably received in a slot in one of said cross-heads, crank pins respectively slidable in other slots in said cross-heads, and separate trains of gearing for moving said crank pins.

17. A reciprocating bed movement comprising a rectilinearly reciprocating bed, a pair of trains of mechanism each comprising a crank arm or its equivalent and each rotated at the same angular velocity, a crank pin thereon, a pinion on said crank pin, a fixed internal gear with which said pinion meshes and within which it rolls, another crank rigid with said pinion and having a crank pin thereon, said trains having different gear and crank arm ratios, means for operatively connecting the last named crank pins of each train with said bed for imparting thereto a motion which is a resultant of the combined motions of said last named crank pins.

18. A reciprocating bed movement comprising a rectilinearly reciprocating bed, a pair of trains of mechanism each comprising a crank arm or its equivalent and each rotated at the same angular velocity, a crank pin thereon, a pinion on said crank pin, a fixed internal gear with which said pinion meshes and within which it rolls, another crank rigid with said pinion and having a crank pin thereon, said trains having different gear and crank arm ratios, means for operatively connecting the last named crank pins of each train with said bed for imparting thereto a motion which is a resultant of the combined motions of said last named crank pins, the gear ratios of the internal gears and the pinions in the case of one train being 3:1 and the other 4:1, and the respective ratios of the last named cranks to the first named crank arms being approximately .58 and .055.

19. A reciprocating bed movement comprising a rectilinearly reciprocating bed, a plurality of trains of mechanism each comprising a crank arm or its equivalent rotated at a constant angular velocity, a crank pin thereon, a pinion on said crank pin, an internal gear with which said pinion meshes and within which it rolls, another crank rigid with said pinion and having a crank pin thereon, a plurality of sliding cross-heads driven by said last named cranks, each having a slot therein within which one of said last named crank pins is adapted to slide during its movement, a rack on said bed, a fixed rack, and a travelling gear adapted to roll upon said fixed rack and mesh with said bed rack, an axle upon which said travelling gear turns, a plurality of arms extending from said axle and each adapted to be driven by one of said sliding cross-heads through crank pins on said arms which are adapted to work in other slots in said cross-heads.

20. In a reciprocating bed movement, the combination with a rectilinearly reciprocating bed of a main driving member for actuating said bed movement and adapted to rotate at a constant angular velocity, transmission mechanism opera-

tively interposed between said member and said bed and adapted to impart to said bed a rectilinear cyclic motion, a substantial portion of which is uniform, said transmission mechanism comprising a plurality of driving elements, means driven by said main driving member to respectively move each of said elements in a separate hypotrochoidal orbit which is symmetrical about its diameter which lies in a plane which is transverse to said bed, a plurality of members adapted to reciprocate in directions parallel to that of the movement of said bed, driving connections between said reciprocating members and said driving elements respectively for giving said reciprocating members rectilinear cyclic motions which are represented by the projections of said hypotrochoidal orbits upon their diameters which are parallel to the plane of movement of said bed; and means for combining the motions of said last named members and transmitting the resultant to said bed.

21. In a reciprocating bed movement, the combination with a rectilinearly reciprocating bed, of a main driving member for actuating said bed movement and adapted to rotate at a constant angular velocity, transmission mechanism operatively interposed between said member and said bed and adapted to impart to said bed a rectilinear cyclic motion, at least one-third of the complete cycle of which is uniform, said transmission mechanism comprising two driving elements, means driven by said main driving member to respectively move each of said elements in a separate hypotrochoidal orbit which is symmetrical about its diameter which lies in a plane which is transverse to said bed, two members adapted to reciprocate in directions parallel to that of the movement of said bed, driving connections between said reciprocating members and said driving elements respectively for giving said reciprocating members rectilinear cyclic motions which are represented by the projections of said hypotrochoidal orbits upon their diameters which are parallel to the plane of movement of said bed; and means for combining the motions of said last named members and transmitting the resultant to said bed, one of said orbits being a prolate hypotrochoid and the other a curtate hypotrochoid.

22. In a reciprocating bed movement, the combination with a rectilinearly reciprocating bed, of a main driving member for actuating said bed movement and adapted to rotate at a constant angular velocity, transmission mechanism operatively interposed between said member and said bed and adapted to impart to said bed a rectilinear cyclic motion, at least one-third of the complete cycle of which is uniform, said transmission mechanism comprising a gear train, a driven element of which has an orbit which is a hypotrochoid which is symmetrical about its diameter which lies in a plane transverse to said bed, a second gear train having a driven element the orbit of which is a hypotrochoid of different characteristics but also symmetrical about its diameter which lies in a plane transverse to said bed; a member reciprocated by said first named element in a straight line path parallel with the direction of movement of said bed in a cycle of movement which is the projection of the movement of said first named element along its hypotrochoidal orbit upon said straight line, a second member reciprocated in a straight line path parallel to said first named path and having a cycle of movement which is the projection of the movement of said second named element upon the second straight line path, and means for combining the motions of said members and imparting the resultant to said bed.

23. A reciprocating bed movement comprising a rectilinearly reciprocating bed; a plurality of trains of mechanism each comprising a crank arm or its equivalent driven at a uniform angular velocity, a pinion rotatably carried on said crank arm, an internal gear, said pinion meshing with and adapted to roll within said internal gear, a crank pin rigidly carried by said pinion; means for driving said first named crank; means for operatively connecting the crank pins of each train of mechanism with said bed and for imparting to the latter a motion which is the resultant of the combined motions of said trains.

24. A reciprocating bed movement comprising a a rectilinearly reciprocating bed; two trains of mechanism each comprising a crank arm or its equivalent driven at a uniform angular velocity, a pinion rotatably carried on said crank arm, an internal gear concentrically disposed with relation to the center of rotation of said crank arm, said pinion meshing with and adapted to roll within said internal gear, a crank pin rigidly carried by said pinion; the crank pin of one of said trains being disposed at a point upon the radius of its pinion, and the crank pin of the other train disposed at a point on the extended radius of its pinion; means for driving said first named crank; means for operatively connecting the crank pins of each train of mechanism with said bed and for imparting to the latter a motion which is the resultant of the combined motions of said trains.

25. A reciprocating bed movement comprising a rectilinearly reciprocating bed; two trains of mechanism each comprising a crank arm or its equivalent driven at a uniform angular velocity, a pinion rotatably carried on said crank arm, an internal gear concentrically disposed with relation to the center of rotation of said crank arm, said pinion meshing with and adapted to roll within said internal gear, a crank pin rigidly carried by said pinion; the crank pin of one of said trains being disposed at a point upon the radius of its pinion, and the crank pin of the other train disposed at a point on the radius extended of its pinion; means for driving said first named crank; means for operatively connecting the crank pins of each train of mechanism with said bed and for imparting to the latter a motion which is the resultant of the combined motions of said trains; said last named means comprising a rack carried by said bed, a stationary rack spaced from and parallel to said bed rack, a travelling gear adapted to roll upon said stationary rack and mesh with said bed rack; a pair of sliding crossheads operatively connected with said travelling gear, and means for respectively driving said crossheads from said crank pins.

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