Jan. 11, 1938. K. K. TURNER 2,105,019

RECIPROCATING ENGINE, PUMP, OR COMPRESSOR OF THE SWASH OR WOBBLE PLATE TYPES

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Fig. 1.

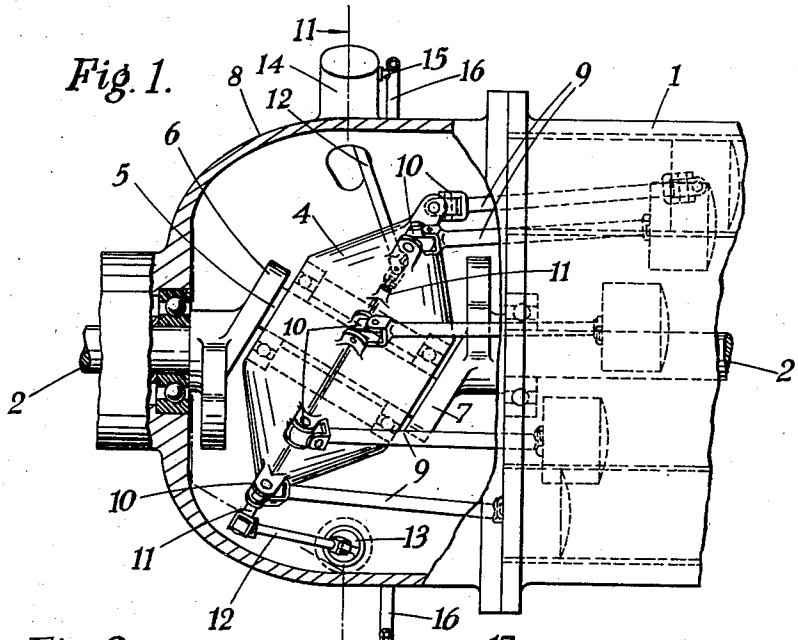

Fig. 2.

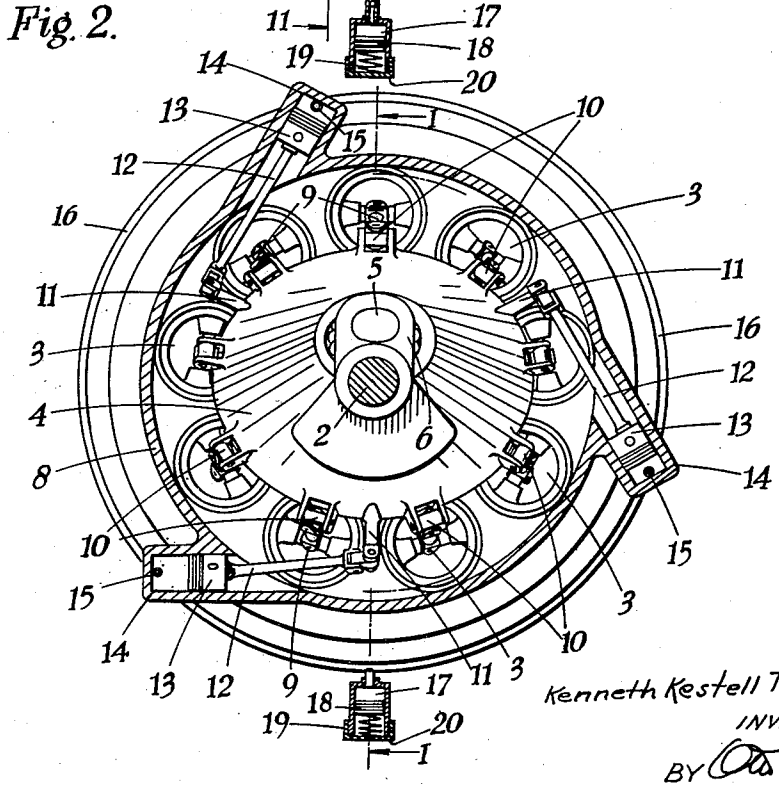

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Fig. 3.

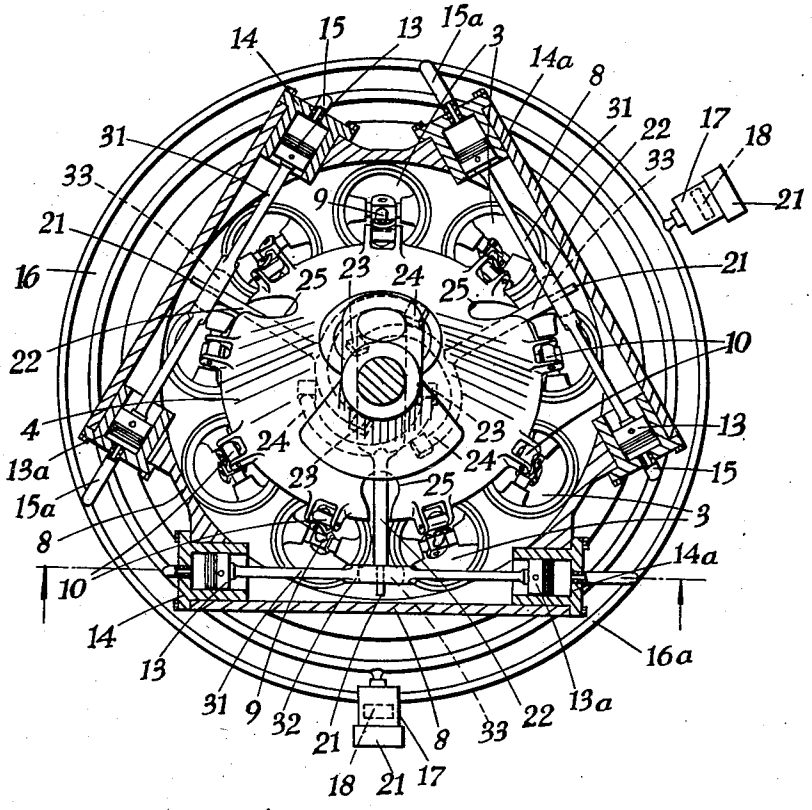
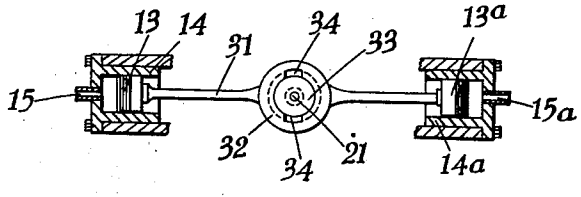


Fig. 4.



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Filed June 1, 1936 3 Sheets-Sheet 3

Fig. 5.

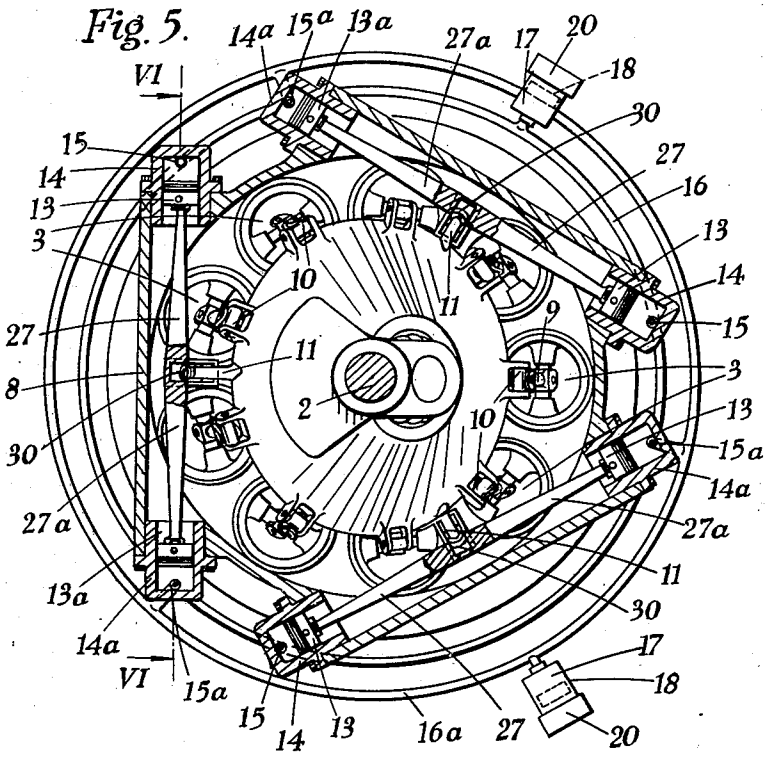


Fig. 6.

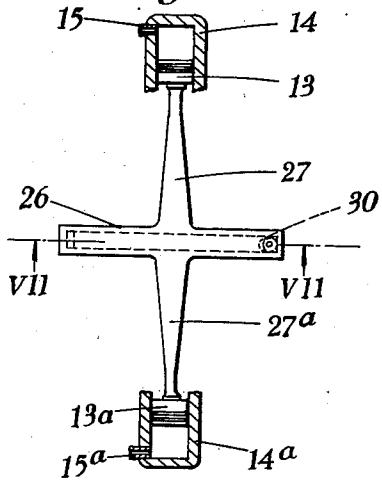


Fig. 7.

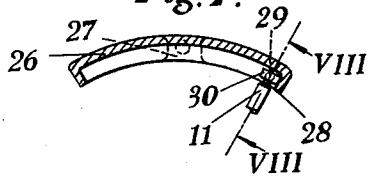
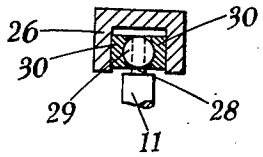


Fig. 8.



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Patented Jan. 11, 1938

2,105,019

UNITED STATES PATENT OFFICE

2,105,019

RECIPROCATING ENGINE, PUMP, OR COMPRESSOR OF THE SWASH OR WOBBLE PLATE TYPES

Kenneth Kestell Turner, London, England

Application June 1, 1936, Serial No. 82,696
In Great Britain June 12, 1935

18 Claims. (Cl. 74—60)

This invention relates to reciprocating engines, pumps or compressors of the axial or barrel type wherein a reciproco-undulatory member (commonly referred to as a swash-plate or wobbler) mounted on a slant-, skew- or Z-shaft is utilized for the conversion of the reciprocating movements of pistons into rotary movement of the shaft or vice versa, and to engines, pumps or compressors of the swash-plate type wherein the pistons are connected to a cage or member fitted with suitable means for the conversion of the reciprocatory movements of the pistons into the rotary movement of a swash-plate or "slant" or vice versa.

In engines, pumps or compressors of the above type hitherto constructed difficulties have been experienced in providing suitable mechanism which will allow the oscillating or wobbling member to oscillate or wobble, without rotating relatively to the pistons, in such a manner that all parts of the oscillating or wobbling member at all times follow simple and undisturbed harmonic paths, such paths being similar for all similar parts of the said member. A mode of preventing the rotation of the oscillating or wobbling member which allows of the member conforming to a natural movement is to provide the member with a suitable ring of teeth meshing with another similar ring of teeth attached to a suitable fixed mounting. This method is not altogether satisfactory in practice owing to breakdown of the teeth caused by the nature of the loads applied to them.

In operation the path of a point on the median plane of an oscillating or wobbling member, when viewed from a position directly in line with the point and the centre of oscillation or wobble, will take the form of a figure-of-eight drawn on the surface of a sphere of radius equal to the radial distance of the particular point from the centre of oscillation or wobble. Consequently, while the oscillating or wobbling member is to be prevented from rotation, the constraint which is applied for this purpose should be of such a nature as to allow the member to follow freely the small tangential oscillations which are components of the said figure-of-eight movement.

An object of the present invention is to provide, in an engine, pump or compressor of the above type, simple and economically constructed means for preventing rotation of the oscillating or wobbling member while allowing the member to conform to a true oscillating or wobbling movement, i. e., a movement in which points on its periphery follow figure-of-eight paths as above mentioned, whereby the elements associated with the member are allowed to operate in a sinusoidal or harmonic manner.

I accomplish the above mentioned object by providing means for preventing the rotation of a reciproco-undulatory member in a reciprocating engine, pump or compressor of the axial or barrel type, which means apply to three or more equiangularly located points about said member, sinusoidally related yielding constraints affording in sum a constant resistance to rotation of said member while allowing said points to follow their normal figure-of-eight paths.

In means as aforesaid the constraints may be applied tangentially and distributed from a common source, as by a fluid, to mechanisms articulated to the member at said points.

I may provide, for preventing rotation of a reciproco-undulatory member, means comprising constraining members articulated to the reciproco-undulatory member at three or more equiangularly located points and disposed substantially tangentially and supported by pistons or plungers slidably mounted in equiangularly spaced tangential cylinders comprised or mounted in the casing of the mechanism, or mounted in other fixed abutment means, with yielding means bearing on the end surfaces of the pistons or plungers within the cylinders.

The aforesaid yielding means preferably comprises a fluid distributed to the cylinders from a common source. Such common distribution source may include a fluid reservoir having preferably adjustable means, such as a spring-loaded plunger, for accommodating the yielding means to conditions of momentary overload.

Alternatively, however, the yielding means may comprise like springs disposed in each of the cylinders to bear on the plungers.

The restraining members in means as aforesaid may be rods universally articulated singly to projections from the periphery of the reciproco-undulatory member and extending in the same sense (i. e., clockwise or counter-clockwise) each to a piston or plunger to which it is also universally articulated.

A variation consists in articulating rods universally in pairs to the aforesaid projections, which rods are disposed to extend in opposite directions each to a piston or plunger.

Under modification, each restraining member may extend tangentially between opposed pairs of pistons or plungers and present an axially disposed slot adapted to receive a slipper pivoted to a projection from the reciproco-undulatory

member at one of said equiangularly located points.

In another modification, members extend tangentially between opposed pairs of pistons and are universally articulated to the outer ends of restraining members having forked inner ends pivoted in the median plane of the reciproco-undulatory member.

Some embodiments of the invention will be described, by way of example with reference to the accompanying diagrammatic drawings, wherein:

Fig. 1 is a fragmentary side elevation of an engine, pump or compressor of the kind referred to, having the casing broken away to show the wobbler mechanism;

Fig. 2 is a sectional end view on the line II—II of Fig. 1;

Fig. 3 is a corresponding sectional end view of another embodiment;

Fig. 4 is a partly sectional view of a detail, on the line IV—IV of Fig. 3;

Fig. 5 is a sectional end view, corresponding to Fig. 2 of yet another embodiment;

Fig. 6 is a partly sectional view of a detail, on the line VI—VI of Fig. 5;

Fig. 7 is a section on the line VII—VII of Fig. 6; and

Fig. 8 is an enlarged section on the line VIII—VIII of Fig. 7.

In the embodiment shown in Figs. 1 and 2, a cylinder block 1 is disposed coaxially about an operative Z-shaft 2, and includes nine equiangularly disposed operative cylinders 3. A wobbler 4 is rotatably mounted on the skew portion 5 of the shaft 2, which portion is securely mounted in oppositely directed webs 6 and 7. A casing 8 houses the wobbler 4. Connecting rods 9 are universally articulated to equiangularly spaced points on the wobbler 4 by means of universal joints 10, and extend to pistons in the cylinders 3.

When the skew portion 5 rotates with the shaft 2, the wobbler 4, without itself rotating, performs a reciproco-undulatory motion. In the course of this movement, each of the joints 10 follows a sinusoidal figure-of-eight path in the surface of a sphere about the centre of oscillation of the wobbler. In order that the movements of the various elements may be of a sinusoidal or harmonic nature, constraint applied to the wobbler 4 to prevent it from rotating must be such as to allow the slight tangential oscillations thereof which are components of the figure-of-eight motion.

For the purpose of the application of such constraint to the wobbler 4, it has three arms 11 projecting from it in equiangular relationship. Rods 12 are universally articulated between the projections 11 and plungers 13 which work in cylinders 14 comprised in or secured to the casing 8. Each cylinder 14 has at or adjacent its outer end a port 15 whereby it communicates with a fluid channel, indicated by a ring of tubing 16, which distributes fluid to the interiors of the cylinders 14. The fluid has access to a cylinder 17, in which is housed a plunger 18 loaded by a compression spring 19. The cylinder 17 has a screw cap 20 whereby the stress of the spring 19 may be adjusted, and a fixed abutment (e. g., the base of the cylinder) limiting the inward movement of the plunger 18.

In operation, each of the projections 11 oscillates in a figure-of-eight path whose major dimension is transverse to the axis of the associated plunger 13. The path has, however, a component parallel to said axis, or tangential, so that the plunger 13 is caused during each complete oscillation of the wobbler 4 to perform two reciprocations in the cylinder 14. Now, since the projections 11 are equiangularly disposed, their movements have a sinusoidal relation, and the sum of the tangential components of said movement will always be zero. Consequently (if the effect of angularity of the rods 12 be ignored) the sum of the volumes of the cylinders 14, above the plungers 13, will be constant, and the fluid in said cylinders will offer constant resistance to the rotation of the wobbler 4, while yieldingly allowing it to follow its figure-of-eight movement.

In order to compensate for any slight variation of the total volume enclosed by the plungers 13 and the cylinders 14, as a result of temporary overload or on account of the varying angularity of the rods 12, the plunger 18 is movable with such variation against or by the spring 19.

In the modification shown in Figs. 3 and 4, members 31 are articulated to reduced portions 21 at the outer ends of forked restraining members 22. The inner ends of the forked members 22 are all pivoted to the interior of the wobbler 4 in the median plane thereof, each member having a limb 23 located nearer the centre of oscillation of the wobbler than its other limb 24. The members 22 project through slots 25 in the shell of the wobbler 4, which slots are of hambone shape (when developed to a plane) since the pivoted ends of the limbs 23 and 24 follow figure-of-eight paths with a difference of phase relative to the similarly moving portions of the wobbler 4 through which the members 22 project. Each of the members 31 extends between plungers 13 and 13a in an opposed pair of cylinders 14 and 14a, which have ports 15 and 15a by which they communicate respectively with distribution channels 16 and 16a each having a cylinder unit 17—20, as shown in Fig. 1, and for the same purpose. The cylinders 14 and 14a are shown detachable from the casing 8. The members 31 have at their middles enlarged portions 32 within which are part-spherical apertures engaged by discs 33 having cooperating part-spherical peripheries and slidably mounted on the reduced outer end portions 21 of the forked members 22.

The enlarged portion 32 of each member 31 has in its aperture a pair of oppositely disposed recesses 34, which enable the disc 33 to be inserted edgewise and then turned through 90° (to the position shown) prior to insertion therein of the end portion 21. This arrangement enables convenient assembly and ensures a trouble-free joint affording universal movement through the limited angles required.

The operation of the means preventing rotation is the same as that previously described. Owing to the equiangular relationship of the members 22, the sum of the sinusoidally related tangential movements of the members 31 is always zero. Thus, although the pairs of plungers 13 and 13a always occupy different relative positions, these positions are governed by a sine law and the total volumes of the spaces enclosed by the plungers 13 and the cylinders 14, and by the plungers 13a and the cylinders 14a, are constant. Consequently, the fluid distributed by the channels 16 and 16a will again prevent rotation of the wobbler 4 while yielding as required to enable it to follow its figure-of-eight motion.

Figs. 5 to 8 show another modification wherein the constraining members are cruciform.

Each comprises an arcuate element 26 supported by two arms 27 and 27a extending tangentially in opposite directions and secured respectively to pistons 13 and 13a in an opposed pair of detachable cylinders 14 and 14a tangentially located in the casing 8. The cylinders have ports 15 and 15a by which they communicate respectively with distribution channels 16 and 16a, as in Fig. 3. The wobbler 4 has projections 11 equiangularly disposed (as in Fig. 1). Each of these projections has at its outer end a reduced portion 28 (Fig. 8) carrying a radially slidable ball 29 in engagement with slippers 30 which are slidable within the slotted element 26.

In the embodiment last described, as the wobbler 4 oscillates from its extreme position as shown (corresponding to the position in elevation of the wobbler shown by Fig. 1) to its other extreme position the slippers 30 engaging the ball 29 mounted on the projection 11 slide along the slotted element 26, whereby rotation of the wobbler 4 is prevented. The constraint applied by the element 26 is, however, of a yielding nature tangentially, i. e. in the common axis of the cylinders 14 and 14a, by virture of the communication of these cylinders with the other cylinders 14 and 14a. As above stated, the positions of the three pistons 13 are sinusoidally related, and also the positions of the three pistons 13a, so that the total volumes enclosed respectively by the pistons 13 and the cylinders 14, and by the pistons 13a and the cylinders 14a remain constant. Thus, while the wobbler 4 is prevented from rotating, under the yielding constraint exercised by the fluid in the cylinders 14 and 14a, it is allowed to move through the tangential components of its figure-of-eight movement.

The embodiments described with reference to Figs. 1 and 2 and Figs. 5–8 are applicable for preventing rotation of a wobbler mounted on a rotating slant-, skew- or Z-shaft, or of a cage or equivalent member which engages the peripheral portion of a rotary swash-plate obliquely secured to the operative shaft of the engine, pump or compressor. On the other hand, the embodiment described with reference to Figs. 3 and 4 is conveniently applicable only for preventing rotation of a wobbler mounted on a rotary slant-, skew- or Z-shaft.

The plungers 13 and 13a are provided with any suitable packing or rings or equivalent for preventing or minimizing leakage of the restraining fluid past them from the closed circuit constituted by the cylinders 14, the channel 16 and the reservoir 17.

Evidently, in a modification of the embodiment shown in Figs. 1 and 2, each of the projections 11 may have attached to it a pair of rods 12 extending in opposite directions and articulated to plungers working in opposed pairs of cylinders like the cylinders 14 and 14a of Fig. 3 or 5.

The embodiments described with reference to Figs. 3 and 4 or Figs. 5–8 may also be modified by associating each of the elements 26 or 31 with only one plunger, such as 13, suitable means being provided for maintaining said element for movement only in the axial direction of its associated plunger.

Moreover, in each of the embodiments and the modifications thereof above described and referred to, the yielding, tangentially-acting constraints may be applied by means of springs instead of fluid. Such springs may, for example, conveniently be housed in barrels located similarly to the cylinders 14 (and 14a). Preferably, the springs are designed and made, in a manner known per se, to have a sinusoidal stress/strain relationship.

It will be evident to those having knowledge of the art that there are various other modifications which may be adopted without departing from the scope of the invention. For example, the yielding constraints may be applied, for preventing rotation of the reciproco-undulatory member, in directions other than tangential. Particularly, three or more rods articulated at equiangularly spaced points to the reciproco-undulatory member may extend, in a common plane and tangentially to a common circle in said plane, to members whereby yielding constraints are applied tangentially, radially or at any other suitable angle relative to the axis of the operative shaft.

I claim:—

1. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a sperical surface, means serving to apply to said member at not less than three equiangularly located points sinusoidally related yielding constraints affording in sum a constant resistance to rotation of said member and allowing said points to follow their figure-of-eight paths.

2. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, a plurality of mechanisms connected with said member at not less than three equiangularly located points, a single pressure-resistant means, and distributor means operatively connecting said pressure-resistant means with said plurality of mechanisms for applying tangentially to said points yielding constraints allowing the points to follow their figure-of-eight paths while preventing rotation of said member.

3. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, a plurality of mechanisms connected with said member at not less than three equiangularly located points, a source of pressure-resistant fluid, and means distributing the resistant pressure of said fluid to apply to said mechanisms tangential yielding constraints allowing said points to follow their figure-of-eight paths while preventing rotation of said member.

4. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising constraining members articulated to said reciproco-undulatory member at not less than three equiangularly located points, plungers associated with said constraining members, cylinders mounted in the machine and housing said plungers, and yielding means bearing on the end surfaces of the plungers within the cylinders to apply tangential yielding constraints through said constraining members to said points.

5. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising constraining members articulated to said reciproco-undulatory member at not less than three equiangularly located points, plungers associated with said constraining members, cylinders mounted in the machine and housing said plungers, a source of pressure-resistant fluid, and means establishing communication between said cylinders and said source and thereby enabling said fluid to apply tangential yielding constraints to said points through said plungers and said constraining members.

6. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising constraining members, articulated to said reciproco-undulatory member at not less than three equiangularly located points, plungers associated with said constraining members, cylinders mounted in the machine and housing said plungers, a source of pressure-resistant fluid, a fluid reservoir in communication with said source, a plunger in said reservoir, loading means on said plunger yieldable to overload on the fluid, and means establishing communication between said cylinders and said source and thereby enabling said fluid to apply tangential yielding constraints to said points through said plungers and said constraining members.

7. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising rods universally articulated to said reciproco-undulatory member at not less than three equiangularly located points and extending tangentially, plungers articulated to said rods, cylinders mounted in the machine and housing said plungers, and yielding means bearing on the end surfaces of the plungers within the cylinders to apply tangential yielding constraints through said rods to said points.

8. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising rods universally articulated to said reciproco-undulatory member at not less than three equiangularly located points and extending tangentially in the same sense, plungers articulated to said rods, cylinders mounted tangentially in the machine and housing said plungers, a source of pressure-resistant fluid, and means establishing communication between said cylinders and said source and thereby enabling said fluid to apply tangential yielding constraints to said points, through said plungers and said rods.

9. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising tangentially disposed rods universally articulated to said reciproco-undulatory member at not less than three equiangularly located points, plungers articulated to said rods, cylinders mounted in the machine and housing said plungers, a source of pressure-resistant fluid, a fluid reservoir in communication with said source, a plunger in said reservoir, loading means on said plunger yielding to overload on the fluid, and means establishing communication between said cylinders and said source and thereby enabling said fluid to apply tangential yielding constraints to said points through said plungers and said rods.

10. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising at least three tangentially disposed constraining members each presenting an axially disposed slot, slipper means engaging said slots and articulated to said reciproco-undulatory member at not less than three equiangularly located points, plungers associated with said constraining members, cylinders mounted in the machine and housing said plungers, and yielding means bearing on the end surfaces of the plungers within the cylinders to apply tangential yielding constraints through said constraining members to said points.

11. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising at least three tangentially disposed constraining members each presenting at its middle an axially disposed slot, slipper means engaging said slots and articulated to said reciproco-undulatory member at not less than three equiangularly located points, plungers secured to both ends of each of said constraining members, cylinders mounted tangentially clockwise and anticlockwise in the machine and housing said plungers, two sources of pressure-resistant fluid, means establishing communication between said clockwise cylinders and one of said sources, and means establishing communication between said anticlockwise cylinders and the other of said sources and thereby enabling said fluid to apply tangential yielding constraints to said points through said plungers and said constraining members.

12. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising at least three tangentially disposed constraining members each presenting at its middle an axially disposed slot, slipper means engaging said slots and articulated to said reciproco-undulatory member at not less than three equiangularly located points, plungers secured to both ends of each of said constraining members, cylinders mounted tangentially clockwise and anticlockwise in the machine and housing said plungers, two sources of pres-

sure-resistant fluid, fluid reservoirs in communication one with each of said sources, a plunger in each of said reservoirs, loading means on each of said plungers yieldable to overload on the fluids, means establishing communication between said clockwise cylinders and one of said sources, and means establishing communication between said anticlockwise cylinders and the other of said sources and thereby enabling said fluid to apply tangential yielding constraints to said points through said plungers and said constraining members.

13. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising at least three members having forked inner ends pivoted equiangularly in the median plane of said reciproco-undulatory member, the outer ends of said forked members extending through slots in the reciproco-undulatory member, tangentially disposed members articulated to said outer ends, plungers associated with said tangentially disposed members, cylinders mounted in the machine and housing said plungers, and yielding means bearing on the end surfaces of the plungers within the cylinders to apply tangential yielding constraints through said tangentially disposed members and said forked members to said reciproco-undulatory member.

14. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising at least three members having forked inner ends pivoted equiangularly in the median plane of said reciproco-undulatory member, the outer ends of said forked members extending through slots in the reciproco-undulatory member, tangentially disposed members articulated to said outer ends, plungers secured to both ends of each of said tangentially disposed members, cylinders mounted tangentially clockwise and anticlockwise in the machine and housing said plungers, two sources of pressure-resistant fluid, means establishing communication between said clockwise cylinders and one of said sources, and means establishing communication between said anticlockwise cylinders and the other of said sources and thereby enabling said fluid to apply tangential yielding constraints through said plungers, said tangentially disposed members and said forked members to said reciproco-undulatory member.

15. In a machine of the type wherein a plurality of pistons are operatively connected with a member to which is imparted a reciproco-undulatory movement such that any point in said member normally follows a figure-of-eight path in a spherical surface, means for preventing rotation of said member comprising at least three members having forked inner ends pivoted equiangularly in the median plane of said reciproco-undulatory member, the outer ends of said forked members extending through slots in the reciproco-undulatory member, tangentially disposed members articulated to said outer ends, plungers secured to both ends of each of said tangentially disposed members, cylinders mounted tangentially clockwise and anticlockwise in the machine and housing said plungers, two sources of pressure-resistant fluid, two fluid reservoirs in communication one with each of said sources, a plunger in each of said reservoirs, loading means on said plungers yieldable to overload on the fluids, means establishing communication between said clockwise cylinders and one of said sources, and means establishing communication between said anticlockwise cylinders and the other of said sources and thereby enabling said fluid to apply tangential yielding constraints, through said plungers, said tangentially disposed members and said forked members to said reciproco-undulatory member.

16. Means for preventing rotation of the reciproco-undulatory member of a machine wherein said member is operatively associated with a plurality of pistons in such manner that any point on said member normally follows a figure-of-eight path in a spherical surface, said means applying to at least three equiangularly located points about said member sinusoidally related yielding constrains affording in sum a constant resistance to rotation of said member and which prevent the rotation while allowing said points to follow their normal figure-of-eight paths.

17. Means for preventing rotation of the reciproco-undulatory member of a machine wherein said member is operatively associated with a plurality of pistons in such manner that any point on said member normally follows a figure-of-eight path in a spherical surface, said means having, in combination, a source of pressure-resistant fluid, distribution means for said fluid, and a plurality of mechanisms serving to apply to said member tangentially at not less than three equiangularly located points yielding constraints exercised by said pressure-resistant fluid.

18. Means for preventing rotation of the reciproco-undulatory member of a machine wherein said member is operatively associated with a plurality of pistons in such manner that any point on said member normally follows a figure-of-eight path in a spherical surface, said means including, in combination, a source of pressure-resistant fluid, at least three equiangularly disposed cylinders, a plunger in each of said cylinders, fluid distribution means connecting said source to said cylinders, and a plurality of like mechanisms connected one with each of said plungers and serving to apply to said member tangentially at a like number of equiangularly located points yielding constraints due to the resistant pressure exercised by said fluid on said plungers.

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