

Dec. 28, 1965

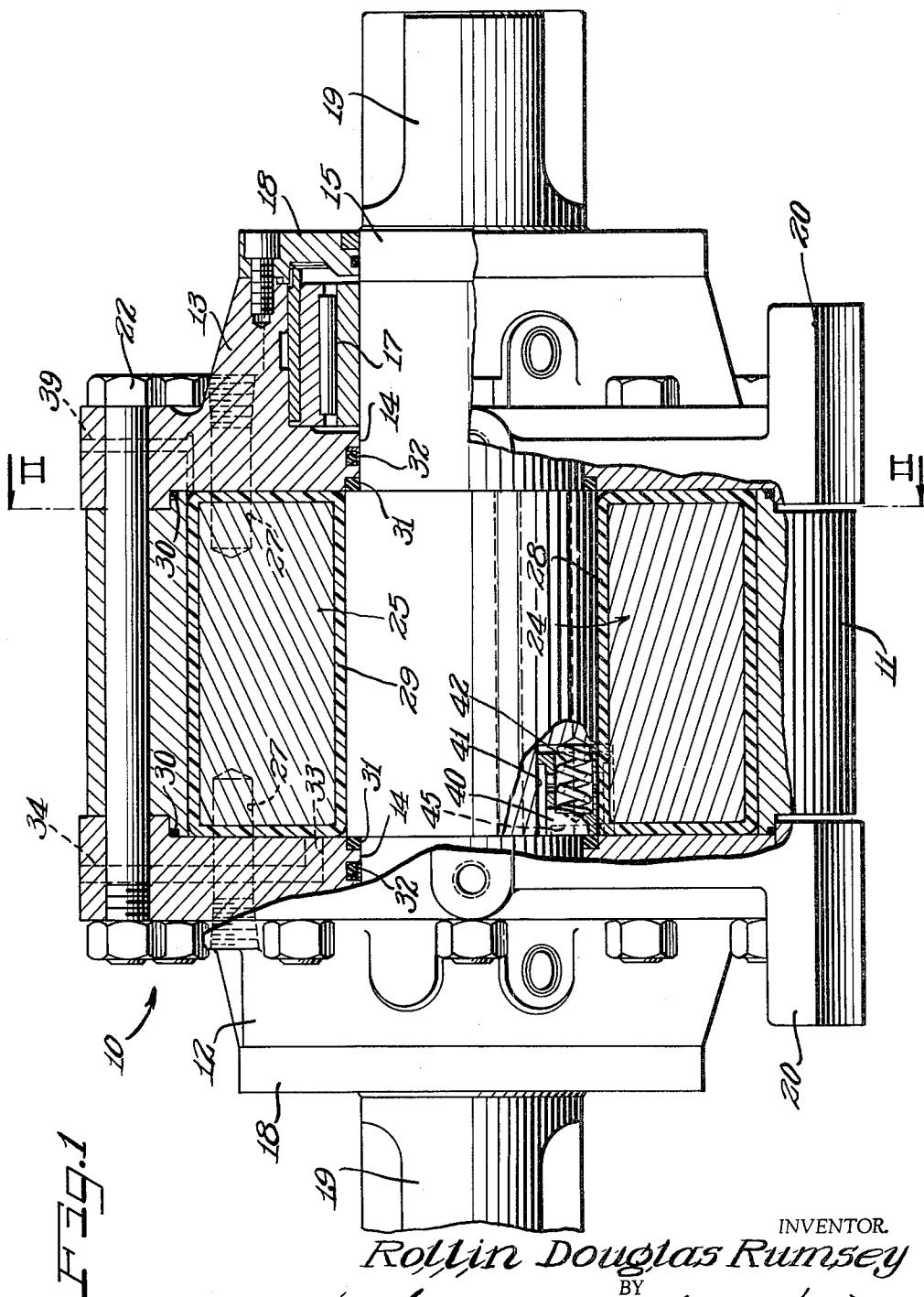
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3,225,664

SNUBBING MEANS FOR ROTARY HYDRAULIC ACTUATORS

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4 Sheets-Sheet 1



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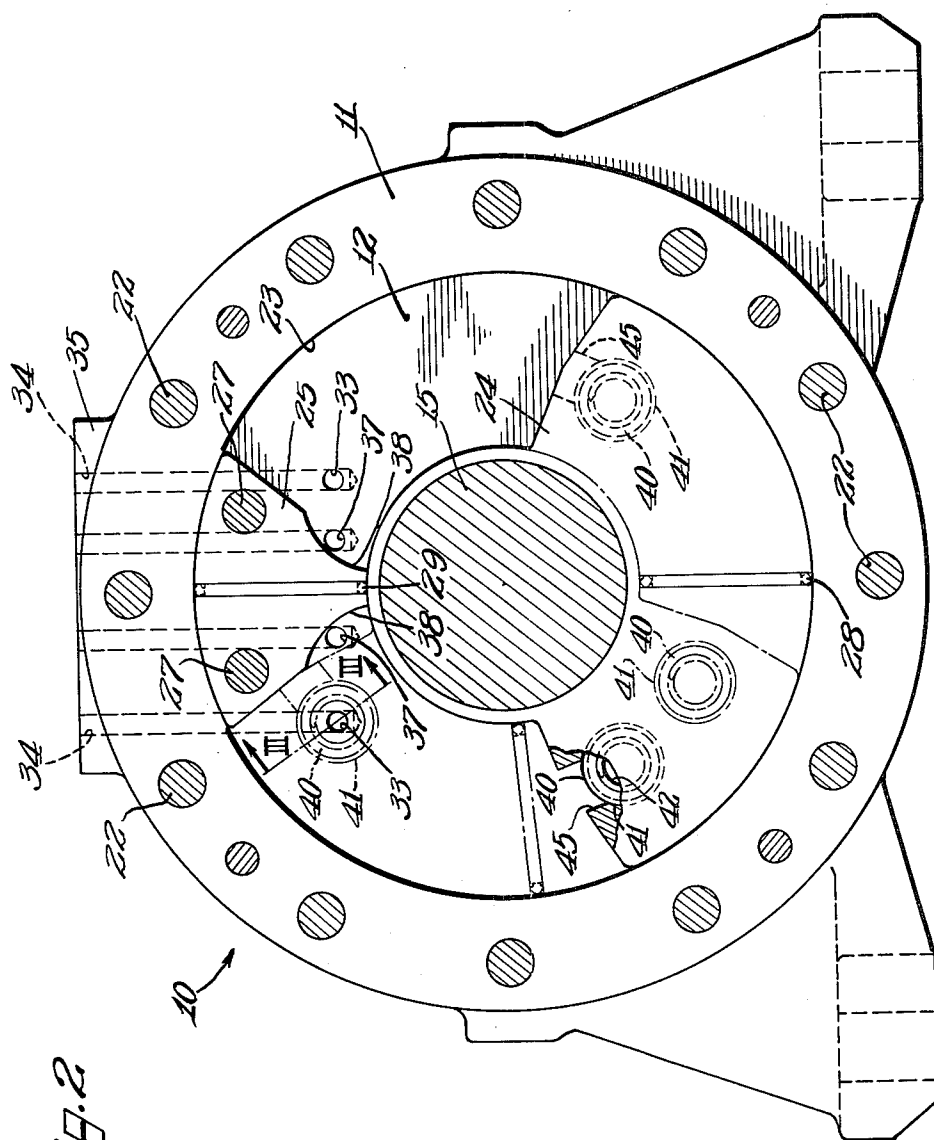


FIG. 2

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Fig. 4

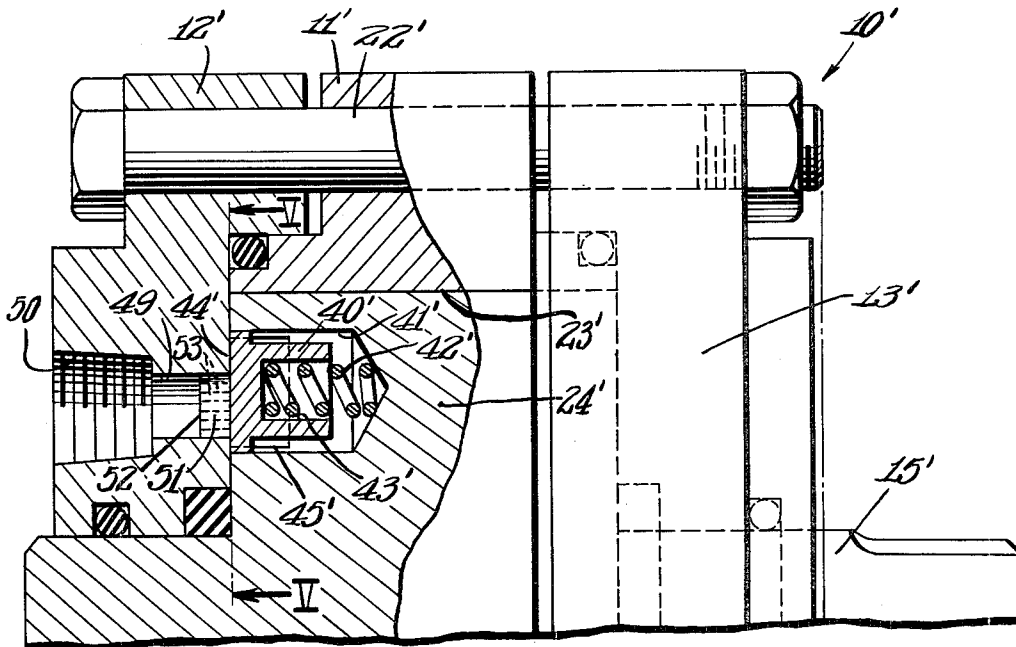
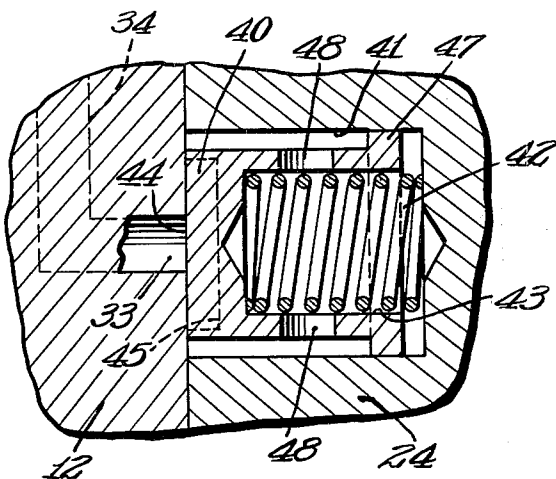


Fig. 3

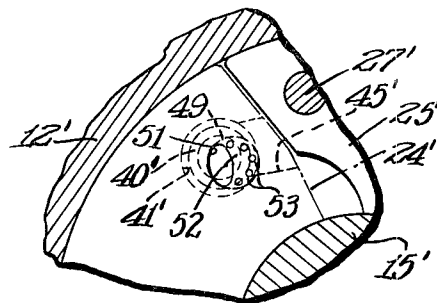


Fig. 5

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4 Sheets-Sheet 4

Fig. 6

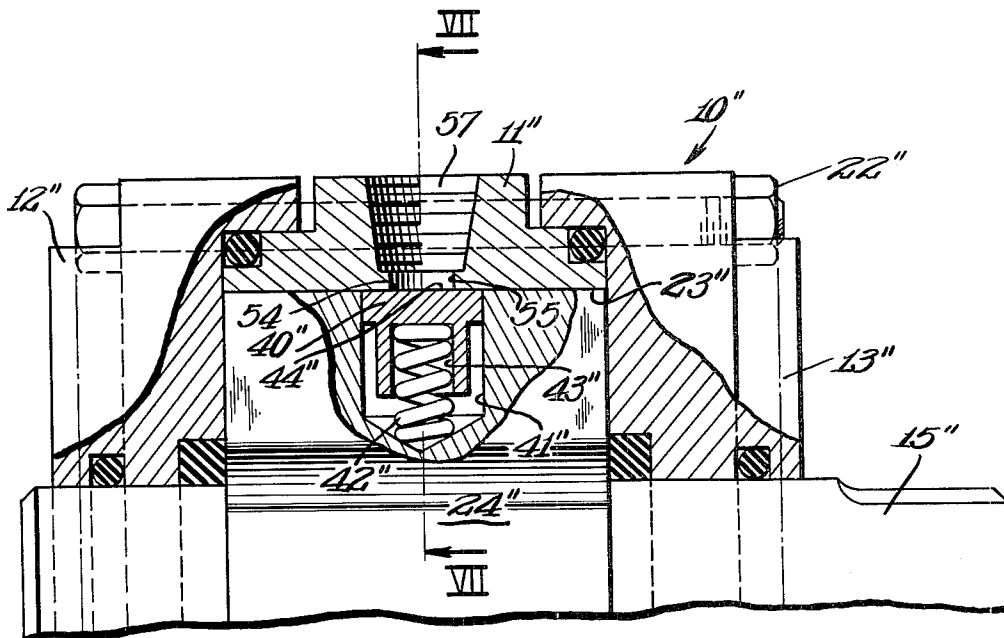
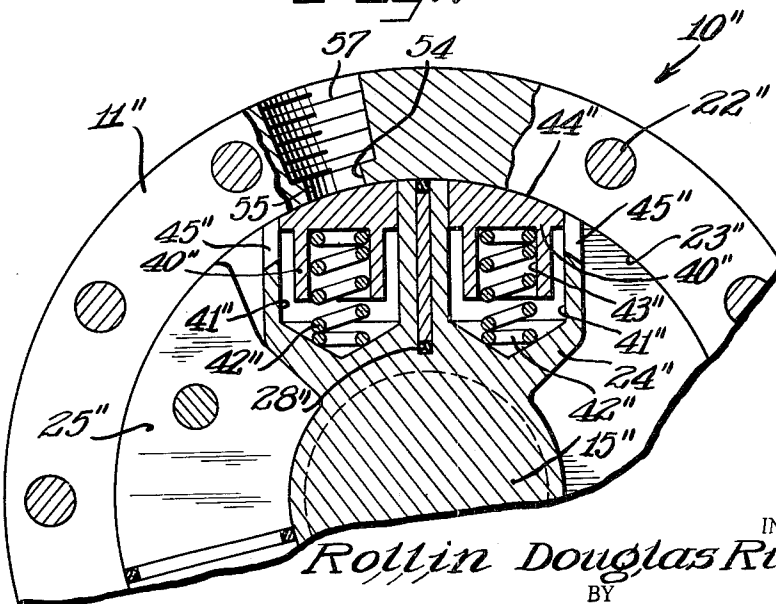


Fig. 7



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SNUBBING MEANS FOR ROTARY HYDRAULIC ACTUATORS

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The present invention relates to improvements in rotary hydraulic actuators and more particularly concerns new and improved means for snubbing the relative motion of the wing shaft and housing at limit of travel.

Rotary hydraulic actuators have extremely high torque and speed capability for their size. When connected to a large inertia load such as a flywheel or long arm, an excessive amount of energy may be transferred to the load mass during operation, resulting in possibly damaging pressure build-up or shocks at the end of stroke or limit of travel.

A system for snubbing the terminal travel of the wing shaft, as disclosed in Patent 2,969,778 issued January 31, 1961, and assigned to the same assignee as the present invention, has been found quite satisfactory for hydraulic rotary actuators of relatively low performance requirements. The patented system utilizes the feature of gradually closing off the outlet port as the travel limit is reached, together with ball check valves to by-pass the closed port to move the wing shaft away from the limit position. However, in high performance actuators of low internal leakage there may be considerable variation in leakage past the closed port owing to tolerance variations. An additional variation may occur as a result of axial float of the shaft. Such variation may be actually so great in practice that in some actuators the port may be closed off tight while in others there is little if any snubbing action.

An important object of the present invention is to provide an improved, simplified snubbing valve arrangement to overcome the variations in snubbing performance as mentioned hereinabove.

Another object of the invention is to provide a new and improved snubbing structure for high performance hydraulic rotary actuators.

A further object of the invention is to provide new and improved snubbing valve means in a rotary hydraulic actuator construction enabling complete elimination of any by-pass passages but enabling the same port to be used for both outlet and inlet purposes, that is, for discharge of hydraulic fluid during travel of the wing shaft vane toward the port, and for delivery of hydraulic fluid under pressure for driving the vane.

Still another object of the invention is to provide new and improved self-adjusting snubber valve means in a hydraulic rotary actuator construction.

Other objects, features and advantages of the present invention will be readily apparent from the following detailed description of certain preferred embodiments thereof taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a side elevational view, partially broken away and in section of a heavy duty rotary hydraulic actuator embodying features of the invention;

FIGURE 2 is a sectional view taken substantially on the line II-II of FIGURE 1;

FIGURE 3 is an enlarged fragmentary sectional detail view taken substantially on the line III-III of FIGURE 2;

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FIGURE 4 is a fragmentary longitudinally sectional detail view through a modification disclosing an arrangement adapted to achieve a controlled snubbing rate characteristic;

FIGURE 5 is a fragmentary sectional elevational detail view taken substantially on the line V-V of FIGURE 4;

FIGURE 6 is a longitudinal sectional detail view through a further modification showing the inlet-outlet port in the ring body of the actuator; and

FIGURE 7 is a transverse sectional detail view taken substantially on the line VII-VII of FIGURE 6.

Referring to FIGURE 1, a heavy duty hydraulic rotary actuator 10 comprises a ring-shaped body 11 having an end cover 12 assembled with one end and an end cover 13 assembled at the opposite end and providing axially aligned therethrough respective bearing apertures 14 through which a wing shaft 15 is journaled. Respective roller bearings 17 are mounted in the end closures 12 and 13 rotatably mounting the shaft 15 and held removably in place in the end members as by means of end caps 18. In this instance, opposite end portions 19 of the shaft 15 project beyond the ends of the actuator and are adapted to be secured operatively to one part of associated apparatus while attachment ears 20 on the end plate members 12 and 13 are adapted to be secured to another part of associated apparatus wherein one of the associated apparatus parts is to be driven rotatably relative to the remaining part of the apparatus. Suitable bolts 22 secure the body ring 11 and the end plate members 12 and 13 into a rigid unitary construction.

Within the casing provided by the housing ring 11 and the end members 12 and 13, a cylindrical working chamber 23 is provided within which a rigidly connected, and in this instance in one piece, vane 24 of the wing shaft 15 is relatively oscillatable within limits defined by an abutment 25 fixedly secured as by means of dowels 27 to the end members 12 and 13 as shown in FIGURES 1 and 2. Although in this instance a single vane actuator is depicted, it will be appreciated that the principles of the present invention are equally applicable to multi-vane actuators.

In order to eliminate or at least minimize internal leakage in operation of the actuator, suitable sealing means 28 are provided between the outer end of the vane 24 which opposes the cylindrical working chamber surface afforded by the body ring 11. Similarly, suitable sealing means 29 are provided between the vane 25 and the opposing surfaces of the body ring 11 and the vane shaft 15. Further, suitable sealing ring means are provided between the body ring member 11 and the end closure members 12 and 13, as shown at 30 and between the end closure members and the wing shaft 15 as at 31 and 32.

Hydraulic fluid for driving the actuator is introduced into the working subchambers defined between the vane 24 and the abutment 25 through respective ports 33 opening thereinto, in this instance through the inner face of the end member 12 suitably adjacent to but spaced from the abutment 25 so as to be covered by a portion of the vane 24 as the vane approaches the abutment at each side. Each of the ports 33 has a passage 34 leading thereto from the outside and in this instance from a land 35 provided on the outer perimeter of the end member 12 as a convenience for connecting to the passages 34 suitable hydraulic conduits (not shown) in a hydraulic system including a suitable pump, control valves and actuating means, none of which are shown because they are well known in the art. Herein the ports 33 serve not only as hydraulic pressure fluid delivery ports but al-

ternatively as outlet or exhaust ports in the operation of the actuator.

In addition, and as an optional feature, respective pressure relief passages 37 ported through the inner face of the closure member 12 within recesses 38 in the opposite sides of the abutment 25 may be provided and connected to external pressure relief valves. In the extreme end of stroke of the vane 24 in both directions the pressure relief passages remain uncovered. Also optionally, air bleeding passage means 39 (FIG. 1) may be provided, as in the end closure member 13 and located high on the actuator to assure at all times a completely hydraulically filled system within the working chamber 23.

According to the present invention, substantially improved snubbing of the vane movement at each side of the abutment 25 is effected by means of a respective sliding shear valve 40 (FIGS. 1, 2 and 3) mounted in the vane 24 for coaction with each of the ports 33. In a convenient form, each of the snubber valves 40 comprises a cylindrical body mounted in a cylindrical blind end guide bore 41 provided in and opening from the face of the vane 24 which opposes the inner face of the closure member 12. Means are provided, desirably in the form of a coiled compression spring 42 seated in a rearwardly opening socket 43 in the body of the valve member 40 and thrusting against the blind end of the bore 41 for biasing the valve member toward the opposing face of the end member 12 so that a front valve face 44 on the valve member maintains a normally firm, close sliding bearing engagement against the end member face. The diameter of the valve member 40 and its valve face 44 is sufficiently large to facilitate manufacture and to minimize wear in operation, and in any event sufficiently larger than the associated hydraulic fluid port 33 to assure coverage of such port in the operating limit of the vane 24 relative to the respective side of the abutment 25 as visualized in FIGURE 3 and as further indicated in dash outline in FIGURE 2. It will be observed that the relative disposition of the respective ports 33 and the snubber valves 40 is such as to assure complete coverage and thus closing off of the port 33 in the final increment of approach of the respective side of the vane to the opposing side of the abutment.

In operation of the actuator 10, hydraulic pressure fluid delivered through one of the ports 33 drivingly relatively separates the wing shaft and the side of the abutment 25 adjacent to such port. Simultaneously, hydraulic fluid is exhausted from the subchamber between the remaining sides of the vane and the abutment through the port 33 communicating therewith. This action may take place at substantial speed and involve high hydraulic pressure. As the approaching side of the vane 24 nears the abutment 25, the valve face 44 of the respective associated snubber valve 40 progressively covers the associated port 33 and thus throttles exhausting discharge flow of hydraulic fluid therethrough until the port is completely covered and the relative rotary movement of the actuator housing and the wing shaft 15 brought to a halt. Since the snubber valve 40 is biased into bearing relation with the opposing end member face any tolerance variables between the opposing faces of the vane and the end member 12 are immaterial and in the fully covered or closing relation of the snubber valve 40 to the port 33 there is near zero leakage.

Enhancement of the sealing thrust of the valve bearing face 44 against the face of the end member 12 is afforded as the snubbing resistance increases by exposing the inner end surfaces, that is, those surfaces which face oppositely to the bearing face 44, of the valve member 40 to the hydraulic fluid between the opposing sides of the vane end abutment. To this end, a communication aperture or slot 45 opens into the valve bore 41 to the adjacent side of the vane 24 and preferably also opens through the face of the vane which opposes the face of the end member 12. A suitable clearance is maintained about

the body of the valve member 40 which for this purpose is of slightly smaller diameter throughout its major extent than the bore 41, with means such as a lateral head flange 47 maintaining the spaced relationship. One or more ports 48 through the side of the valve member 40 into the spring socket 43 afford free communication for hydraulic fluid entering by way of the port 45 to reach all surfaces of the valve member which face oppositely to the valve bearing face 44. Since such oppositely facing surfaces are greater in area than the area of the bearing face 44, a normal pressure differential develops in supplement to the biasing spring 42 for biasing the valve face 44 into sealing engagement with the end member face. This supplemental fluid biasing effect is especially desirable during the snubbing coaction of the valve member with the port 33 and is actually enhanced by the further unbalancing effect of exposure of the valve face 44 to the low pressure or bleed-off area afforded by the port.

A second major feature and function of the snubber valve 40 resides in its ability to back-off or lift away from the associated port 33 when the hydraulic pressure is reversed in the operation of the actuator 10. Thus the valve 40 serves as a check valve and permits full hydraulic pressure fluid flow to by-pass the valve instantaneously by shifting or blowing off of the valve away from the port in opposition to the biasing spring 42 and initial escape of the hydraulic pressure fluid through the side communication passage slot 45 into the sub-chamber working area between the vane and the abutment within the actuator housing. Hence, there is quick response actuation of the actuator, with the valve 40 moving beyond the port 33 in the separating movement of the adjacent side of the vane and abutment. This eliminates any need for check valved cross-porting in the wing shaft.

Special snubbing rate characteristics are easily achieved by the present invention through special port shapes and by multiple orifice patterns. For example, in FIGURES 4 and 5 the actuator 10' may in general respects be substantially similar to the actuator 10, including a body ring 11' and end closure members 12' and 13' secured together as by means of bolts 22' and defining a working chamber 23' within which the vane 24' of the wing shaft 15' is operable between opposite sides of the abutment 25' secured in place by the dowels 27'. The snubber valve 40' mounted in the blind end guide bore 41' and biased by the spring 42' seated in the spring socket 43' has its sealing bearing face 44' thrusting against the opposing face of the end member 12', with a communication slot 45' opening through the side of the vane from the valve bore 41'.

Pressure fluid delivery and alternatively exhaust of pressure fluid is effected by way of a passage 49 in the end plate cover member 12', in this instance communicating with a threaded counterbore 50 opening through the end of the end member for reception of a suitable hydraulic pressure conduit coupling. In this instance, the passage 49 is of a larger diameter than a delivery-outlet port 51 opening through a partition 52 which extends across the inner end of the passage flush with and comprising part of the inner face of the end member 12'. In this instance, the port 51 is of a shape other than circular, and here shown as of a generally oblong form which will afford a desirable snubbing rate characteristic as the port is progressively covered by the sliding shear valve face 44' as the vane 24' approaches the limit of its stroke relative to the abutment 25'. As a further snubbing rate control feature, one or more, and in this instance a plurality of small cross-sectional flow area orifices 53 are provided in the partition 52 in any preferred drilled hole pattern and located between the main port 51 and the adjacent side of the abutment 25' so as to become effective in the snubbing action of the snubber valve 40' after it has covered the main port 51. By such graduated sizes of the ports and orifices and a predetermined pattern for progressive sliding shearing covering of the same by the snubber

valve, any desired snubbing rate characteristic can be attained.

Instead of having the hydraulic fluid delivery-outlet ports located in one of the end members of the actuator, it may be desirable, or required to have such ports enter through the wall of the ring body of the actuator, as exemplified in FIGURES 6 and 7 wherein the actuator 10" has the ring body 11" with opposite end closure members 12" and 13" journalling the wing shaft 15" and secured to the body by the bolts 22". Within the working chamber 23" the wing shaft vane 24" oscillates between opposite sides of the abutment 25" in the operation of the actuator.

Hydraulic fluid connection with the working chamber 23" is effected at the respective opposite sides of the abutment 25" by means of respective ports 54 (only one of which is shown) opening through the cylindrical wall of the ring body 11" defining the working chamber 23". Each of the ports 54 has a passage 55 provided at its outer end with a threaded counterbore 57 to receive a hydraulic pressure conduit coupling.

In the actuator 10", the vane 24" has the snubber valves 40" mounted in the valve bores 41" opening through its end face which opposes the inner surface of the ring body 11" and with one of the snubber valves located in spaced relation at each side of the seal 28". In this instance, the bearing valve faces 44" are curved complementarily to the curve of the opposing body wall surface. The springs 42" seated in the respective sockets 43" thrust the surfaces 44" firmly sealingly into engagement with the opposing body surface and the valves 40" slidably shear flow through the respective ports 54 as the vane 24" reaches the limit of approaching movement to the abutment 25". The sidewardly opening slots 45" function the same as the slots 45 in FIGURES 1-3.

It will thus be apparent that the present invention provides a substantially improved yet simplified snubbing valve means which overcomes variations in snubbing performance experienced with prior arrangements.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. In a rotary hydraulic actuator construction including a housing defining a working chamber having an abutment therein with a hydraulic fluid exhaust port in a wall surface defining the chamber adjacent to the abutment and located to be covered by a vane relatively oscillatably responsive to hydraulic pressure fluid within the working chamber to effect relative oscillation of the housing and a wing shaft assembled therewith, the improvement comprising:

a snubber valve mounted in the vane and biased into sliding shear engagement with said wall surface for progressively closing off said port as the vane and abutment reach the limit of relative movement toward one another.

2. In a rotary hydraulic actuator construction including a housing defining a working chamber having an abutment therein with a hydraulic fluid exhaust port in a wall surface defining the chamber adjacent to the abutment and located to be covered by a vane relatively oscillatably responsive to hydraulic pressure fluid within the working chamber to effect relative oscillation of the housing and a wing shaft assembled therewith, the improvement comprising:

a snubber valve mounted in the vane and having sliding shear engagement with said wall surface for progressively closing off said port as the vane and abutment reach the limit of relative movement toward one another, and means normally biasing said valve toward said sliding shear engagement.

3. In a rotary hydraulic actuator construction including a housing defining a working chamber having an abut-

ment therein with a hydraulic fluid exhaust port in a wall surface defining the chamber adjacent to the abutment and located to be covered by a vane relatively oscillatably responsive to hydraulic pressure fluid within the working chamber to effect relative oscillation of the housing and a wing shaft assembled therewith, the improvement comprising:

a snubber valve mounted in the vane and having sliding shear engagement with said wall surface for progressively closing off said port as the vane and abutment reach the limit of relative movement toward one another,

and a biasing spring normally thrusting said valve toward said sliding engagement.

4. In a rotary hydraulic actuator construction including a housing defining a working chamber having an abutment therein with a hydraulic fluid exhaust port in a wall surface defining the chamber adjacent to the abutment and located to be covered by a vane relatively oscillatably responsive to hydraulic pressure fluid within the working chamber to effect relative oscillation of the housing and a wing shaft assembled therewith, the improvement comprising:

a snubber valve mounted in the vane and having sliding shear engagement with said wall surface for progressively closing off said port as the vane and abutment reach the limit of relative movement toward one another,

and means for impressing fluid pressure onto said valve for biasing it toward said sliding engagement.

5. In a rotary hydraulic actuator construction including a housing defining a working chamber having an abutment therein with a hydraulic fluid exhaust port in a wall surface defining the chamber adjacent to the abutment and located to be covered by a vane relatively oscillatably responsive to hydraulic pressure fluid within the working chamber to effect relative oscillation of the housing and a wing shaft assembled therewith, the improvement comprising:

a snubber valve mounted in the vane and having sliding shear engagement with said wall surface for progressively closing off said port as the vane and abutment reach the limit of relative movement toward one another,

and means for normally biasing said valve toward said sliding engagement including

a biasing spring,

and passage means exposing surfaces of the valve facing oppositely to the surface of the valve which effects said sliding engagement to fluid pressure for supplementing the biasing thrust of said spring.

6. In a rotary hydraulic actuator construction including a housing defining a working chamber having an abutment therein with a hydraulic fluid exhaust port in a wall surface defining the chamber adjacent to the abutment and located to be covered by a vane relatively oscillatably responsive to hydraulic pressure fluid within the working chamber to effect relative oscillation of the housing and a wing shaft assembled therewith, the improvement comprising:

said vane having a blind end guide bore of substantially larger diameter than said port and opening toward said wall surface in an area of the vane which substantially registers with said port in the limit of relative movement of the vane and abutment toward one another,

a valve member slidably guided in said bore for limited axial movement therein and having an end surface slidably conforming to said wall surface and being of larger area than the cross-sectional flow area of said bore at said surface,

and means for biasing said valve member toward said wall surface so that in the relative movement of the

vane and abutment toward one another said end face surface will shearingly progressively close said port.

7. In a rotary hydraulic actuator construction including a housing defining a working chamber having an abutment therein with a hydraulic fluid exhaust port in a wall surface defining the chamber adjacent to the abutment and located to be covered by a vane relatively oscillatably responsive to hydraulic pressure fluid within the working chamber to effect relative oscillation of the housing and a wing shaft assembled therewith, the improvement comprising:

said vane having a blind end guide bore of substantially larger diameter than said port and opening toward said wall surface in an area of the vane which substantially registers with said port in the limit of relative movement of the vane and abutment toward one another,

a valve member slidably guided in said bore for limited axial movement therein and having an end surface slidingly conforming to said wall surface and being of larger area than the cross-sectional flow area of said bore at said surface,

means for biasing said valve member toward said wall surface so that in the relative movement of the vane and abutment toward one another said end face surface will shearingly progressively close said port, said vane having an opening through its side nearest said bore communicating the bore with fluid pressure in said chamber between the vane and abutment,

and said valve member having fluid pressure receiving surfaces facing oppositely to said end surface and exposed to the fluid pressure communicated through said opening.

8. In a rotary hydraulic actuator construction including a housing defining a working chamber having an abutment therein with a hydraulic fluid exhaust port in a wall surface defining the chamber adjacent to the abutment and located to be covered by a vane relatively oscillatably responsive to hydraulic pressure fluid within the working chamber to effect relative oscillation of the housing and a wing shaft assembled therewith, the improvement comprising:

said vane having a blind end guide bore of substantially larger diameter than said port and opening toward said wall surface in an area of the vane which substantially registers with said port in the limit of relative movement of the vane and abutment toward one another,

a valve member slidably guided in said bore for limited axial movement therein and having an end surface slidingly conforming to said wall surface and being of larger area than the cross-sectional flow area of said bore at said surface,

means for biasing said valve member toward said wall surface so that in the relative movement of the vane and abutment toward one another said end face surface will shearingly progressively close said port, said vane having an opening through its side nearest said bore communicating the bore with fluid pressure in said chamber between the vane and abutment, and said valve member having fluid pressure receiving surfaces facing oppositely to said end surfaces and exposed to the fluid pressure communicated through said opening for biasing the valve member toward said wall surface,

said port also serving as a hydraulic pressure fluid delivery port and said valve member being movable in opposition to its bias when driven by pressure fluid from said opening affording a discharge passage for pressure fluid escaping past the valve member from the port.

9. A rotary hydraulic actuator as defined in claim 7, wherein said actuator housing comprises an end closure member and said wall surface is on said end closure

member and said port is in said end closure member, with the area of the vane having said bore opposing the closure member.

10. A rotary hydraulic actuator as defined in claim 8, wherein said actuator housing comprises an end closure member and said wall surface is on said end closure member and said port is in said end closure member, with the area of the vane having said bore opposing the closure member.

11. A rotary hydraulic actuator construction as defined in claim 7, wherein said housing includes a generally ring-shaped housing body and said wall surface is on said housing body with the port opening through said surface in the housing body and the vane area is on the end of the vane which opposes such body surface, said valve surface being contoured in conformity with the contour of the ring-shaped body surface.

12. A rotary hydraulic actuator construction as defined in claim 8, wherein said housing includes a generally ring-shaped housing body and said wall surface is on said housing body with the port opening through said surface in the housing body and the vane area is on the end of the vane which opposes such body surface, said valve surface being contoured in conformity with the contour of the ring-shaped body surface.

13. In a rotary hydraulic actuator construction including a housing defining a working chamber having an abutment therein with a hydraulic fluid exhaust port in a wall surface defining the chamber adjacent to the abutment and located to be covered by a vane relatively oscillatably responsive to hydraulic pressure fluid within the working chamber to effect relative oscillation of the housing and a wing shaft assembled therewith, the improvement comprising:

a snubber valve mounted in the vane and biased into sliding shear engagement with said wall surface for progressively closing off said port as the vane and abutment reach the limit of relative movement toward one another,

said housing having a passage of substantially larger cross-sectional flow area than the port and leading to the port through the housing,

and a partition across the passage in the plane of said wall surface and slidingly engageable by said snubber valve,

said part extending through said partition in communication with said passage.

14. In a rotary hydraulic actuator construction including a housing defining a working chamber having an abutment therein with a hydraulic fluid exhaust port in a wall surface defining the chamber adjacent to the abutment and located to be covered by a vane relatively oscillatably responsive to hydraulic pressure fluid within the working chamber to effect relative oscillation of the housing and a wing shaft assembled therewith, the improvement comprising:

a snubber valve mounted in the vane and having sliding shear engagement with said wall surface for progressively closing off said port as the vane and abutment reach the limit of relative movement toward one another,

said housing having a passage of substantially larger cross-sectional flow area than the port and leading to the port through the housing,

and a partition across the passage in the plane of said wall surface,

said port extending through said partition in communication with said passage,

said partition also having at least one orifice therethrough in addition to said port and in a pattern with the port for attaining predetermined snubbing rate characteristic in the shearing progressive closing movement of the valve member across the partition.

15. A rotary hydraulic actuator as defined in claim 1, wherein said port is specially shaped to attain a predeter-

mined snubbing rate characteristic as the valve progressively closes it.

16. A rotary hydraulic actuator as defined in claim 1, wherein the housing comprises a generally ring-shaped body member and opposite end members mounted thereon and defining said working chamber, said wall surface being on one of said end members, and the other of said end members having air bleeding passage means located high on the actuator to assure at all times a completely hydraulically filled system within the working chamber.

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