Sept. 20, 1960 T. BUDZICH 2,953,099

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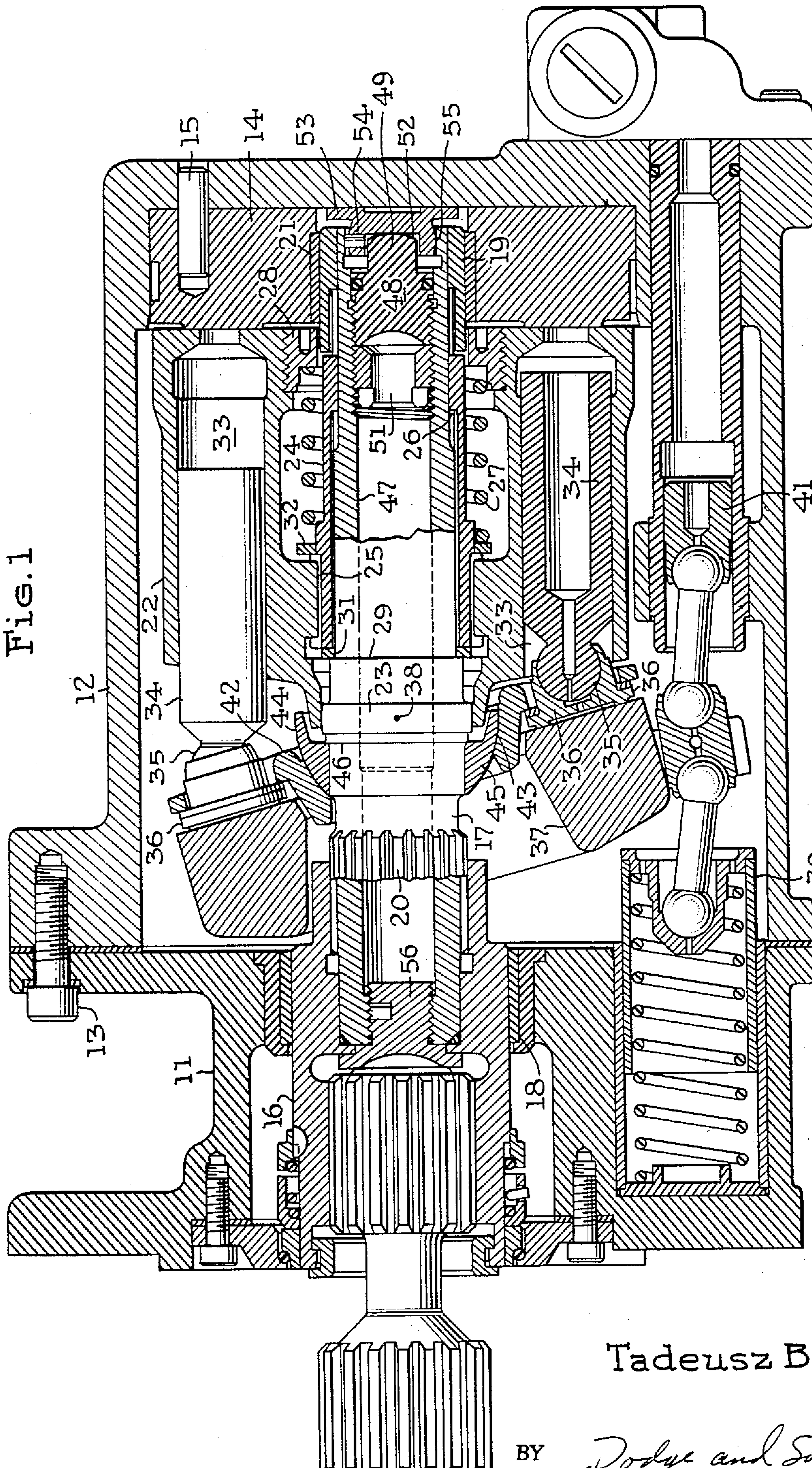

Fig. 1

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Fig. 2

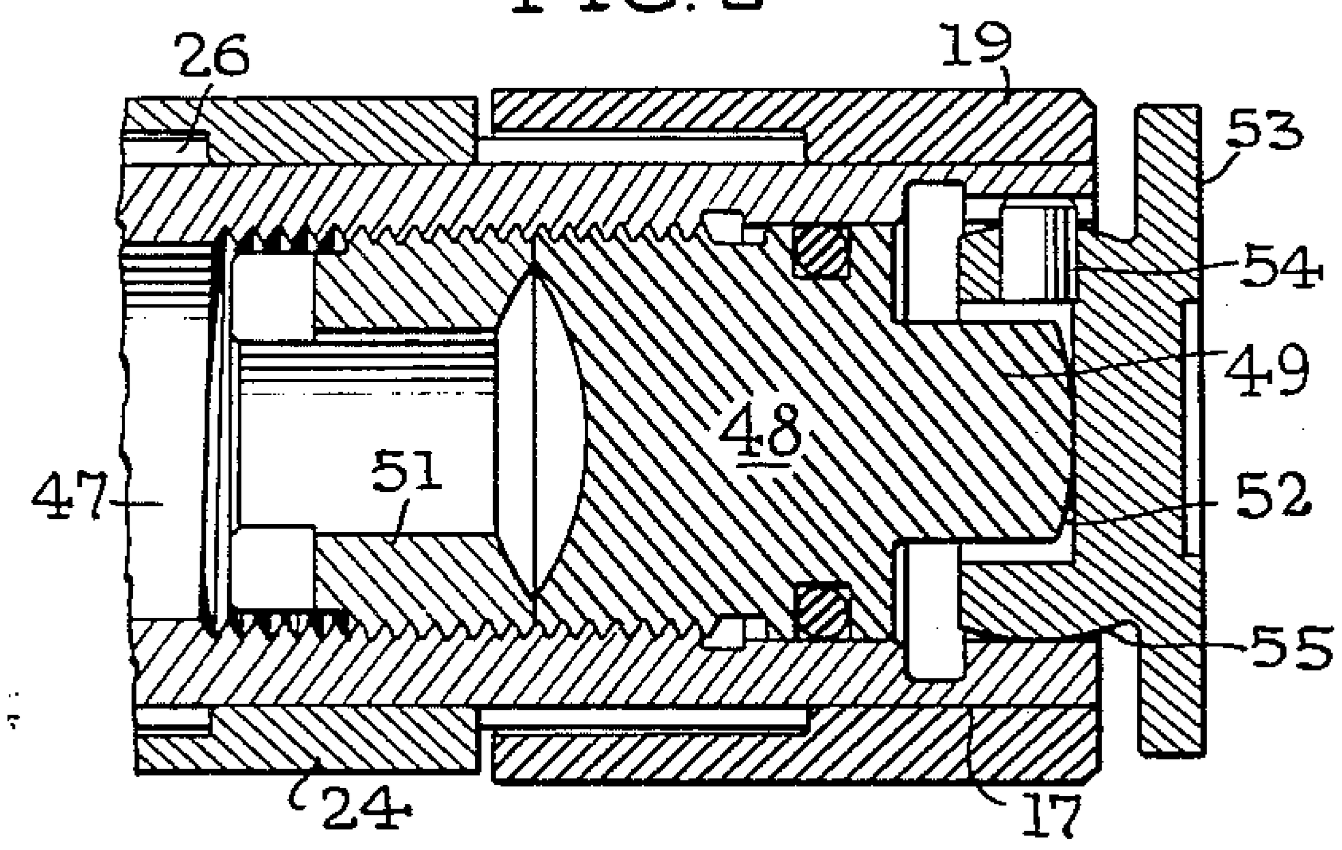


Fig. 3

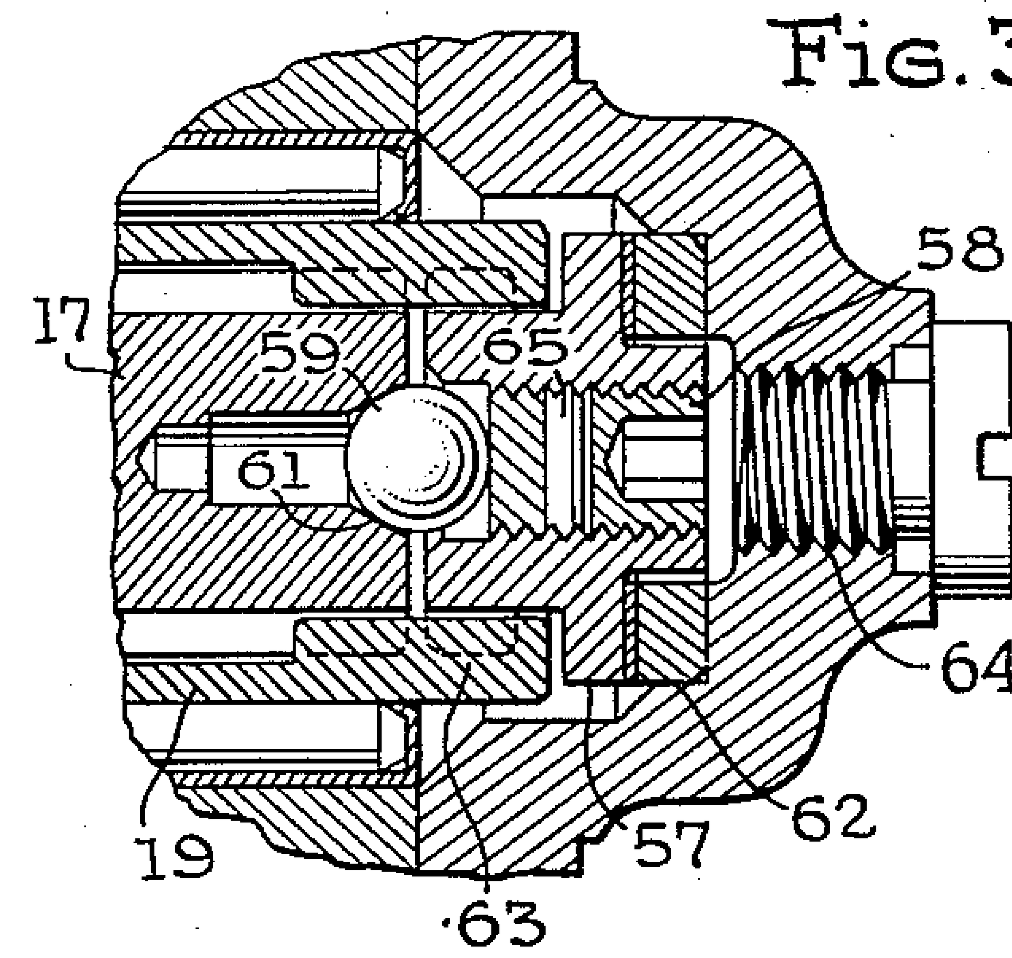
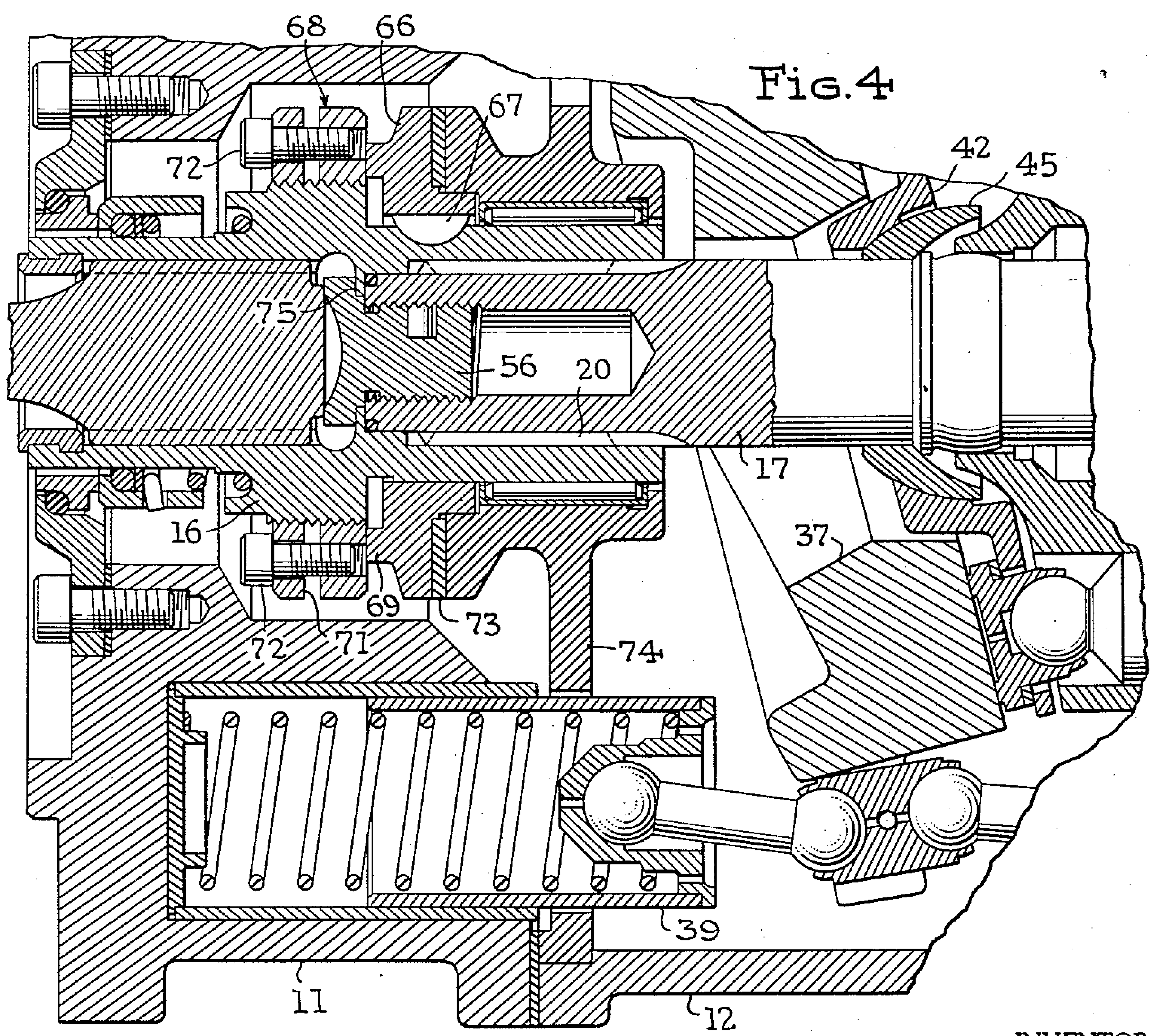


Fig. 4



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United States Patent Office

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4 Claims. (Cl. 103—162)

This invention relates to fluid pressure pumps and more particularly to pumps of the type including a rotary cylinder barrel and a plurality of longitudinally reciprocating pistons.

In pumps of this type, the pistons are usually reciprocated by an inclined cam plate which moves them on their discharge strokes and a nutating plate which moves them on their suction strokes. The nutating plate is universally mounted on a supporting collar which encircles the drive shaft and which is freely slidable in a longitudinal direction thereon. The pump also includes a biasing spring reacting between the cylinder barrel and the supporting collar for urging the pistons into operative engagement with the cam plate and for urging the cylinder barrel into contact with a ported valve plate located adjacent one of its end faces. It is thus seen that the spring serves two separate functions, viz: it prevents separation between the pistons and the cam plate and it provides a sealing force between the cylinder barrel and the valve plate during starting conditions.

Pumps of the type mentioned perform satisfactorily at low speeds but when the pump is operating at high speeds and the inertia loads transmitted to the nutating plate by the pistons are high, the biasing spring compresses and allows the pistons to leave the cam plate. The resultant hammering of the pistons on the cam plate causes serious maintenance problems and limits the usefulness of the pump. In order to minimize this effect, various methods of increasing the size of the biasing spring have been employed. This approach, however, is not rewarding because as the spring force is increased, so too is the sealing force between the cylinder barrel and the valve plate and consequently, the friction force acting between these members becomes very large. Most of these pumps are provided with a balancing film of oil between the cylinder barrel and the valve plate but since this film is effective only when the pump is operating, it can be seen that a large friction force would make it difficult to start the pump. Therefore, as a practical matter, the biasing spring must be designed to afford the best compromise between these two conflicting functions and accordingly, the operating speed of the pump will be limited.

The object of this invention is to provide a pump of the type mentioned in which the pistons are maintained in operative engagement with the cam plate regardless of operating speed, and in which the magnitude of the sealing force urging the cylinder barrel into contact with the valve plate can be selected to effect adequate sealing without causing undue friction. Briefly, the invention consists in constraining the nutating plate support against longitudinal movement relatively to the shaft and in providing a thrust bearing between the shaft and the housing for supplying the reactive force for the piston inertia loads transmitted to the shaft by the nutating plate and its supporting collar. Compared with the biasing spring, the housing affords a relatively unyielding reaction surface and therefore the difficulties stemming from the hammering effect, mentioned above, are avoided. Furthermore, since the biasing spring now performs only one function, it can be designed solely with respect to this function and optimum sealing can be realized.

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In the preferred form of the invention, one portion of the thrust bearing is longitudinally adjustable so that after the pump is assembled, the shaft, supporting collar and nutating plate may be moved in a longitudinal direction to bring the pistons into operative engagement with the cam plate. In this way, manufacturing tolerances can be reduced and the adverse effects of their accumulation during assembly can be avoided.

Another feature of the invention relates to the provision of a universal support for that portion of the thrust bearing carried by the shaft so that the mating faces of the bearing members will remain in contact even though the shaft deflects during operation.

The invention will now be described in more detail with reference to the accompanying drawings, in which:

Fig. 1 is an axial section of a variable displacement pump employing a first embodiment of the invention.

Fig. 2 is an enlarged sectional view of the thrust bearing shown in Fig. 1.

Fig. 3 is a sectional view of a second form of thrust bearing suitable for use in the Fig. 1 embodiment.

Fig. 4 is a sectional view of a third embodiment of the invention.

Referring to Fig. 1, the pump comprises a housing having two separable sections **11** and **12** formed with mating flanges connected by bolts **13**. The right end of the section **12** is bored to receive a conventional ported valve plate **14** which is constrained against rotation by pin **15**. A two-part drive shaft, having telescoping sections **16** and **17** connected by splines **20**, extends through the housing and is journalled at its left end in the bearing **18** fitted in housing section **11**. The right end of the shaft is splined to a collar **19** which is supported by bearing **21** mounted in valve plate **14**.

A rotary cylinder barrel **22** is universally supported on the drive shaft by spherical enlargement **23** and is connected in driven relation with the shaft by torque tube **24** and splines **25** and **26**. This method of supporting and driving the cylinder barrel is more fully described and claimed in applicant's copending application Serial No. 656,574, filed may 2, 1957. Surrounding the torque tube is a biasing spring **27** which reacts against adjustable seat **28** for urging the cylinder barrel into contact with valve plate **14**. The opposite end of the spring is supported by shaft **17** via shoulder **29**, washer **31**, splines **25** and washer **32**. The cylinder barrel contains a circumferential series of longitudinal cylinder bores **33** which extend through the barrel for receiving pistons **34**. At its left end, each piston **34** is formed with a spherical head **35** for universally supporting a piston shoe **36**. An adjustable cam plate **37** is supported in the housing section **12** by trunnion and yokes (not shown) for angular adjustment about an axis extending in a direction normal to the axis of the drive shaft and intersecting that axis at the point of intersection **38** of the plane of the centers of the spherical piston heads and the axis of the drive shaft. The lower end of the cam plate **37** is universally connected with spring plunger **39** and motor piston **41** which cooperate to vary its angular position about the above-mentioned axis.

A nutating plate **42**, loosely connected with each the piston shoes **36**, contains a central spherical recess **43** which cooperates with the outer surface **44** of the collar **45** to form a universal support for the nutating plate. The centers of the surfaces **43** and **44** are located at the point **38** mentioned above. The collar **45** abuts against annular shoulder **46** formed on the shaft. As will appear from the following description, the collar **45** functions as an integral part of the drive shaft **17** but, because of manufacturing considerations, it is made a separate part, as shown.

Drive shaft section **17** contains an axial bore **47** having a threaded portion, as shown. A plug **48**, having a centrally projecting portion **49**, is screwed into the threaded portion of the bore **47** and held in place by a lock nut **51**. The end of the projecting portion **49** is formed with a spherical surface **52** for universally supporting a bearing plate **53**. The plate **53** is connected in driven relation with the shaft section **17** by a pin **54** which engages a longitudinal groove formed in the surface of bore **47**. The outer peripheral surface **55** of the bearing plate engages loosely the surface of bore **47** and is formed in the shape of a sphere to permit relative rocking motion between this member and the drive shaft.

After the pump has been assembled, a suitable tool would be inserted into the left end of bore **47** for turning the plug **48** and advancing it to the right. This movement will bring surface **52** in contact with bearing plate **53** and will bring the latter into contact with the end wall of housing section **12**. Further advancement of the plug **48** will move the shaft **17** to the left causing shoulder **46**, acting through collar **45** and nutating plate **42**, to bring piston shoes **36** into abutment with the surface of cam plate **37**. When this adjustment is complete, the lock nut **51** would be screwed into engagement with plug **48** and a sealing plug **56** would be threaded into the left end of bore **47**.

During operation, rotation of cylinder barrel **22** will cause cam plate **37** to move the pistons **34** on their discharge strokes, and nutating plate **42**, acting through the shoes **36**, to move the pistons on their suction strokes. The inertia of the pistons **34** will exert a force on the nutating plate **42** acting toward the right (as viewed in Fig. 1) and this force will be transmitted to the drive shaft by collar **45** and shoulder **46**. The inertia forces will then travel through the support plug **48** and bearing plate **53** into the housing section **12**. It is thus apparent that no matter how large these inertia forces may be, they are resisted by the housing **12** and consequently, the shoes **36** will always remain in contact with the surface of cam plate **37**.

It should be noted that biasing spring **27**, acting through washer **32**, splines **25**, washer **31**, shoulders **29** and **46**, collar **45** and nutating plate **42**, also transmits a force to shoes **36** urging them into contact with cam plate **37**. However, this force is not large enough to maintain contact between the shoes and the cam plate and acts on the shoes merely as an incident of providing a reaction seat for spring **27**. In other words, in order for spring **27** to urge cylinder barrel **22** into abutment with valve plate **14**, it is necessary to provide a reaction surface for the spring, and since the path just described affords the most convenient reaction surface, it is used.

Fig. 3 illustrates a second form of thrust bearing which could be used in the pump of Fig. 1. In this embodiment, the bearing plate **57** contains a central threaded bore for receiving an adjustable plug **58**. The end face of the plug contacts a ball **59** which is seated in a conical bore **61** formed in the right end of shaft **17**. A stationary bearing **62**, located in alignment with plate **57**, is pressed into a bore in the end wall of housing section **12**. The bearing plate **57** is connected in driven relation with shaft **17** by splines **63** and collar **19**.

In the Fig. 3 embodiment, the longitudinal position of the shaft is adjusted by inserting a wrench through the bore **64** in the end wall of the housing and turning the plug **58** so that it advances to the left. In this way, the bearing plate **57** will be forced to the right into abutment with stationary bearing **62**, and the shaft will be moved to the left to place the shoes **36** in contact with cam plate **37** as previously described. The adjusted position of plug **58** is maintained by a conventional nylon lock **65** and the bore **64** is sealed by an O-ring and plug as shown. The inertia loads transmitted to the shaft by the nutating plate are delivered to the housing by ball **59**, plug **58**, bearing plate **57** and stationary bearing **62**.

Fig. 4 illustrates a third embodiment of the invention. In this case, the thrust bearing is located at the left end of the drive shaft and comprises an annular bearing plate **66** encircling the shaft section **16** and connected to this section by key **67**. Since deflections of shaft section **17** will not be transmitted to section **16**, because of the inherent looseness in splines **20**, it is not necessary to provide a universal support for the bearing plate **66**. A nut **68** is threaded on the outer peripheral surface of shaft section **16** and abuts against an annular land **69** formed on the plate **66**. The nut contains a circumferential groove **71** and a plurality of locking screws **72** which, when tightened, cause the nut to distort and the threads to bind, thereby locking the nut. The stationary bearing **73** of the thrust bearing is carried by an intermediate wall **74** which is securely clamped between the housing sections **11** and **12** when they are assembled.

When the nut **68** is turned so that it advances to the right, the bearing members **66** and **73** are forced into contact. Further advancement of the nut moves the shaft section **16** to the left, the key **67** sliding in the longitudinal groove provided in bearing member **66**. Since the flange **75** of the shaft section **16** is clamped between the plug **56** and the end of the shaft section **17**, the shaft section **17** will follow the movements of section **16**. When the parts are in proper position, the screws **72** would be tightened to lock the nut **68** in place. The piston loads transmitted to the shaft by the nutating plate **42** and collar **45** are delivered to the housing **12** via plug **56**, flange **75**, nut **68**, bearing members **66** and **73**, and intermediate wall **74**.

It can now be seen that in each of the three embodiments of the invention, the thrust bearing, shaft and nutating plate supporting collar provide a rigid, unyielding force transmitting link for conveying the piston inertia loads to the pump housing. Thus, the pistons in each embodiment will always be maintained in contact with the cam plate. Furthermore, the provision of this force path eliminates one of the heretofore essential functions of biasing spring **27**, and therefore this spring can now be designed solely with regard to the sealing requirements between the cylinder barrel and valve plate.

It can also be seen that the above-mentioned rigid force transmitting link carries only the inertia forces of the pistons. The thrust or hydraulic loads (which for each piston equals the pressure in cylinder bore **33** multiplied by the cross-sectional area of the piston) are transmitted to the housing through the cam plate **37** and its yokes and trunnions (not show).

Since the drawings and description relate only to three of many possible embodiments of this invention, and since many changes in the structure of these embodiments can be made without departing from the inventive idea, the following claims should provide the sole meansure of the scope of the invention.

What is claimed is:

1. In a pump of the type including a housing, a drive shaft journalled in the housing, a rotary cylinder barrel connected in driven relation with but being free to move longitudinally of the drive shaft, a plurality of reciprocable pistons mounted in longitudinal cylinder bores formed in the cylinder barrel, a stationary valve face located in a plane extending in a direction normal to the axis of rotation and containing inlet and outlet ports which communicate sequentially with each cylinder bore as the cylinder barrel rotates, a spring biasing the cylinder barrel into contact with the valve face, a cam plate supported by the housing for moving the pistons on their discharge strokes, and a nutating plate for moving the pistons on their suction strokes and in which the hydraulic loads of the pistons are transmitted to the housing through the cam plate and the inertia loads of the pistons tend to move the nutating plate in a longitudinal direction, the improvement which comprises means forming a rigid force-

transmitting link between the nutating plate and the shaft; and means forming a rigid force-transmitting link between the shaft and the housing, whereby the inertia loads of the pistons are transmitted to the housing through the nutating plate and the shaft without producing relative longitudinal movement between the nutating plate and the housing.

2. The improvement defined in claim 1 in which the inner end of the drive shaft is spaced from a wall of the housing and the shaft is formed with an axial bore having a threaded portion adjacent the inner end of the shaft, and in which the means forming a rigid force transmitting link between the shaft and the housing comprises a bearing support threaded in the bore; a thrust bearing mounted for universal movement on the support; means connecting the bearing in driven relation with the shaft but permitting free longitudinal movement of it relatively to the shaft; and a bearing surface in alignment with the thrust bearing and supported by the said wall of the housing.

3. The improvement defined in claim 1 in which the means forming a rigid force transmitting link between the shaft and the housing comprises a spherical member carried by the inner end of the shaft and centered on the shaft axis; a thrust bearing mounted for universal movement on the spherical member; means connecting the bearing in driven relation with the shaft but permitting free longitudinal movement of it relatively to the shaft; a bearing surface in alignment with the thrust bearing and supported by the housing; and an adjustable threaded member coaxial with the shaft and reacting between the shaft and the thrust bearing through the spherical member for moving the thrust bearing into contact with the bearing surface and for causing the shaft and nutating plate to move the pistons into operative engagement with the cam plate.

4. The improvement defined in claim 1 in which the means forming a rigid force transmitting link between the shaft and the housing comprises a thrust bearing; means connecting the bearing in driven relation with the shaft but permitting free longitudinal movement of it relatively to the shaft; a bearing surface in alignment with the thrust bearing and supported by the housing; means adjustable in the longitudinal direction and reacting between the thrust bearing and the shaft for moving the thrust bearing into contact with the bearing surface and for causing the shaft and nutating plate to move the pistons into operative engagement with the cam plate; and locking means for maintaining the adjustable means in its adjusted position.

References Cited in the file of this patent

UNITED STATES PATENTS

895,961	Case	Aug. 11, 1908
941,834	Wing	Nov. 30, 1909
1,239,057	Sparks	Sept. 4, 1917
1,242,744	Trautman	Oct. 9, 1917
1,362,040	Pratt	Dec. 14, 1920
1,688,825	Mills	Oct. 23, 1928
1,839,497	Petuson	Jan. 5, 1932
2,776,628	Keel	Jan. 8, 1957

FOREIGN PATENTS

267,265	Great Britain	Mar. 17, 1927
534,773	France	Jan. 12, 1922
539,939	Germany	Nov. 26, 1931
574,612	Germany	Mar. 23, 1933

OTHER REFERENCES

MacDuff: abstract of application Serial No. 717,764, published October 31, 1950, 639 O.G, 1661.