Feb. 6, 1951 G. A. UNGAR 2,541,010

GEAR PUMP OR MOTOR

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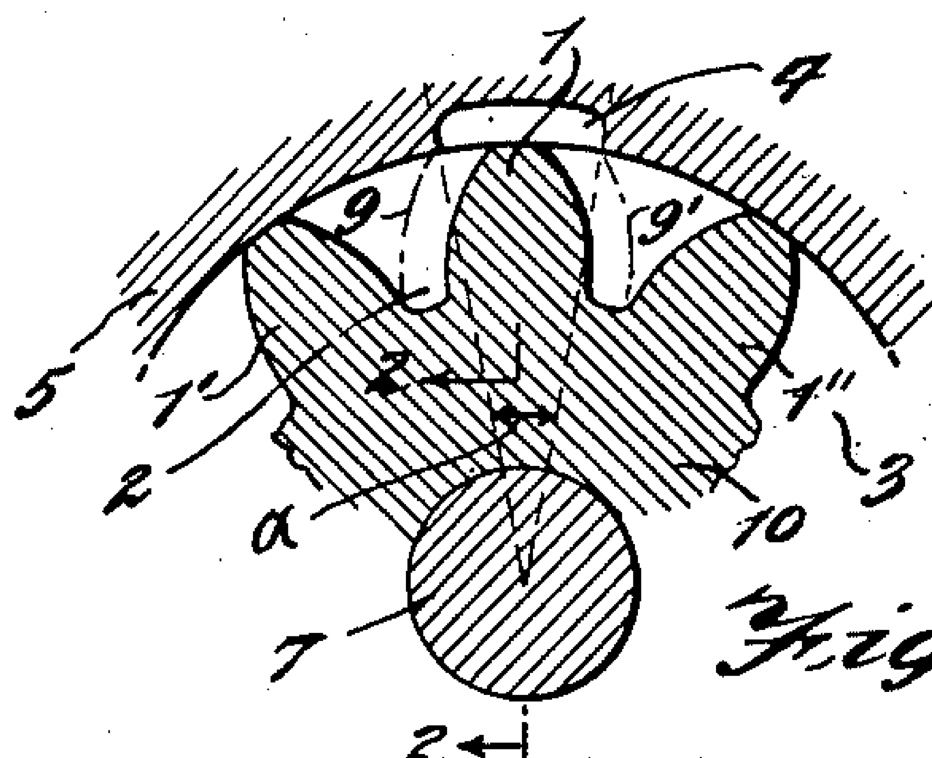


Fig. 1.

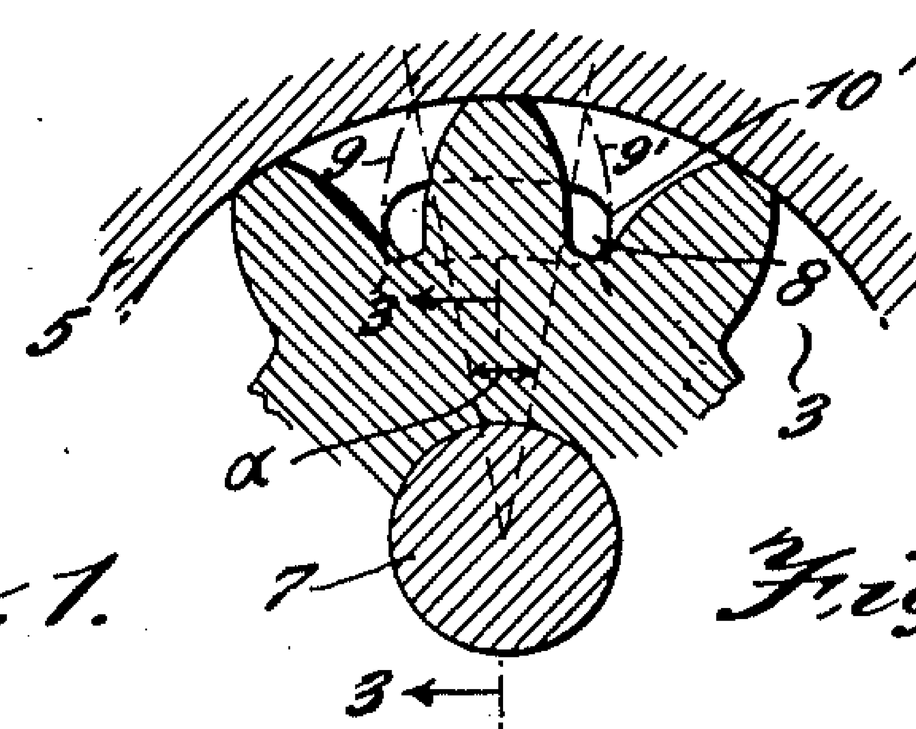


Fig. 3.

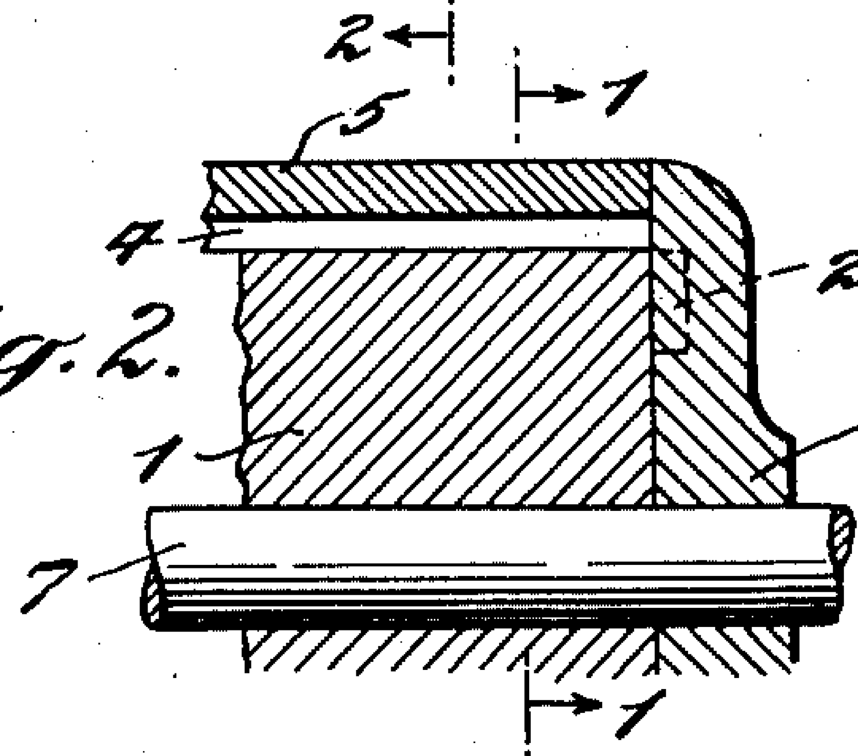


Fig. 2.

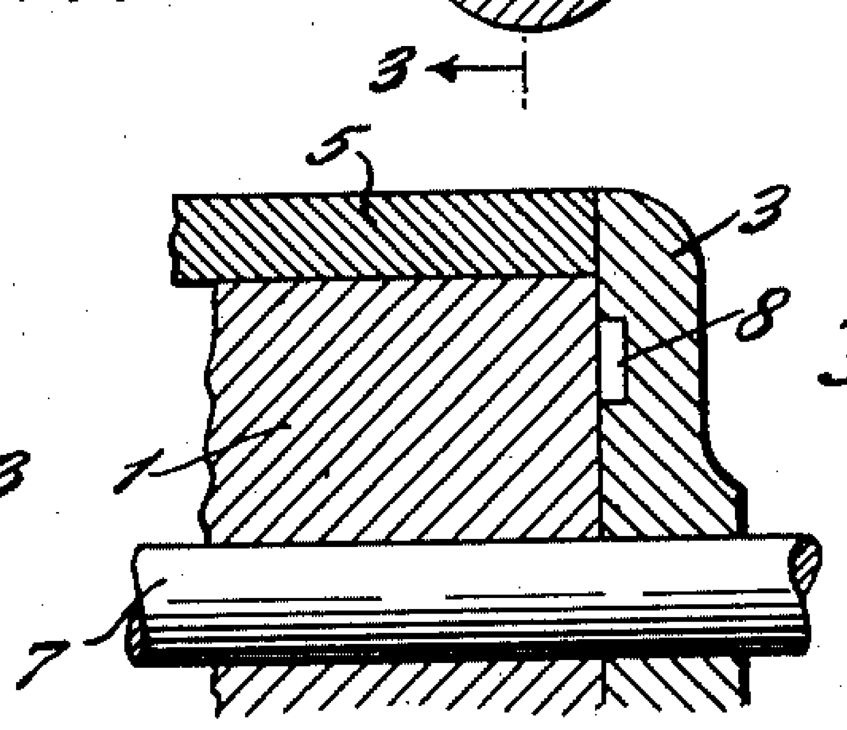


Fig. 4.

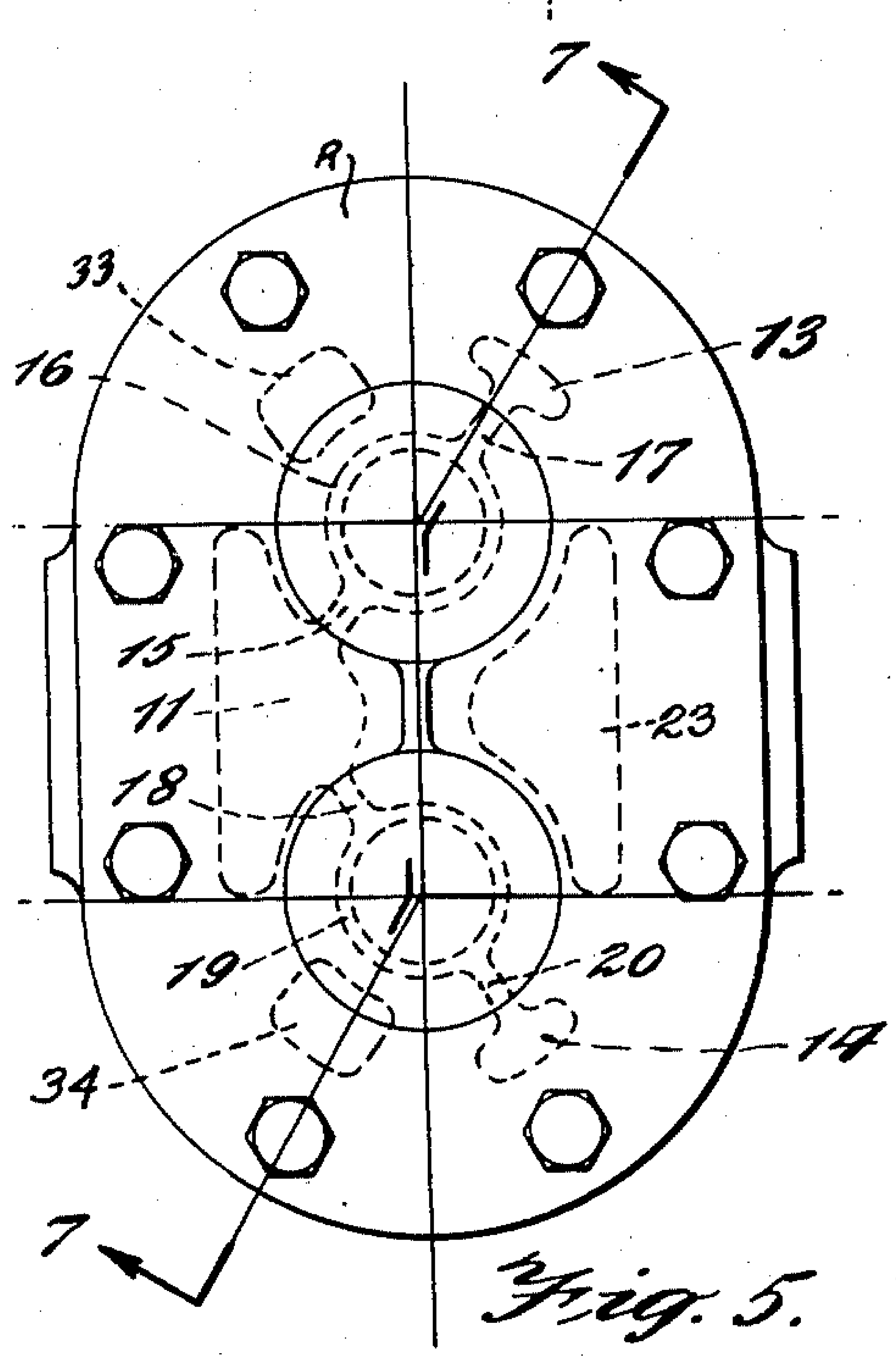


Fig. 5.

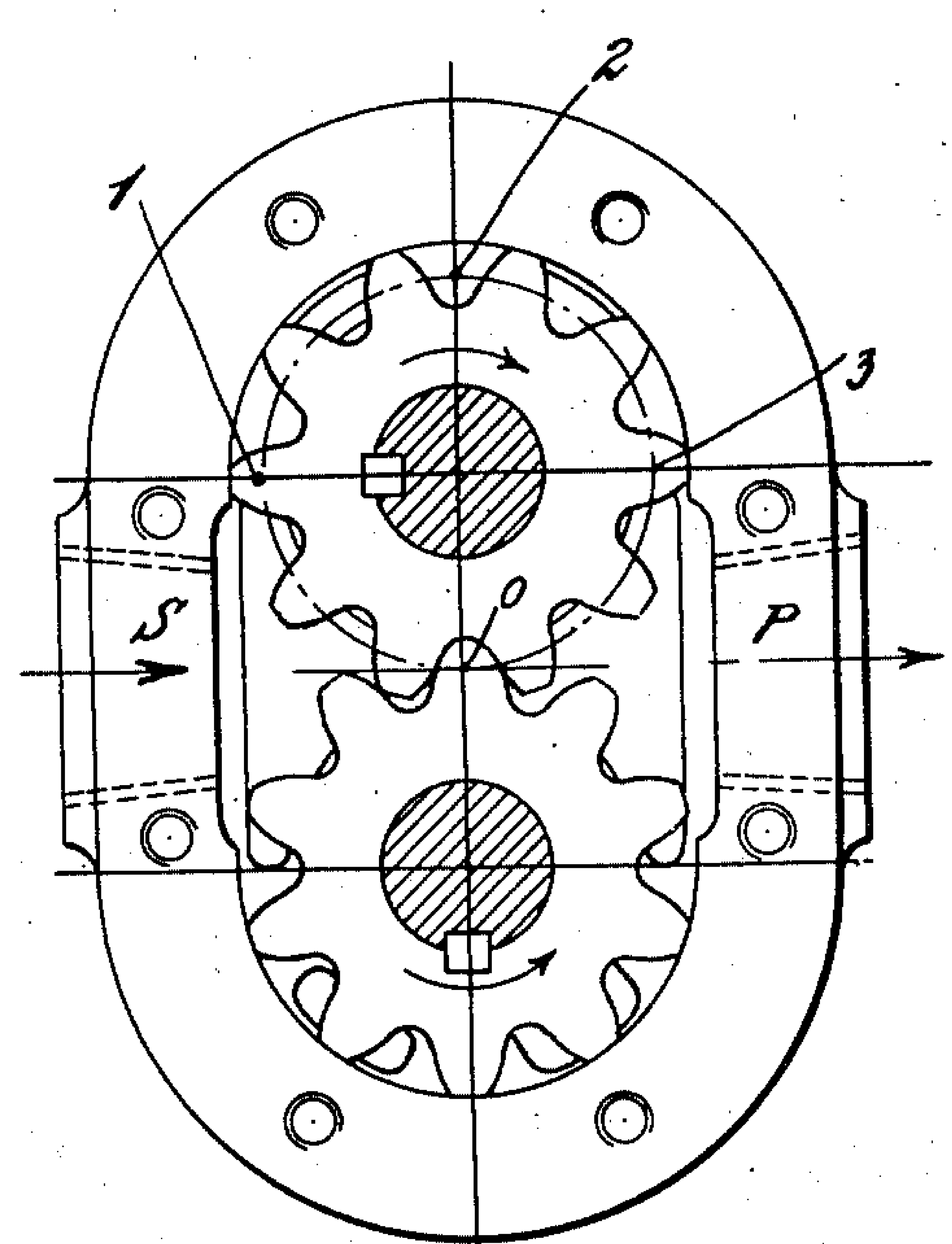


Fig. 6.

INVENTOR.
Gustave A. Ungar

BY
Lackenbach & Hirschman
ATTORNEYS

Fig. 7.

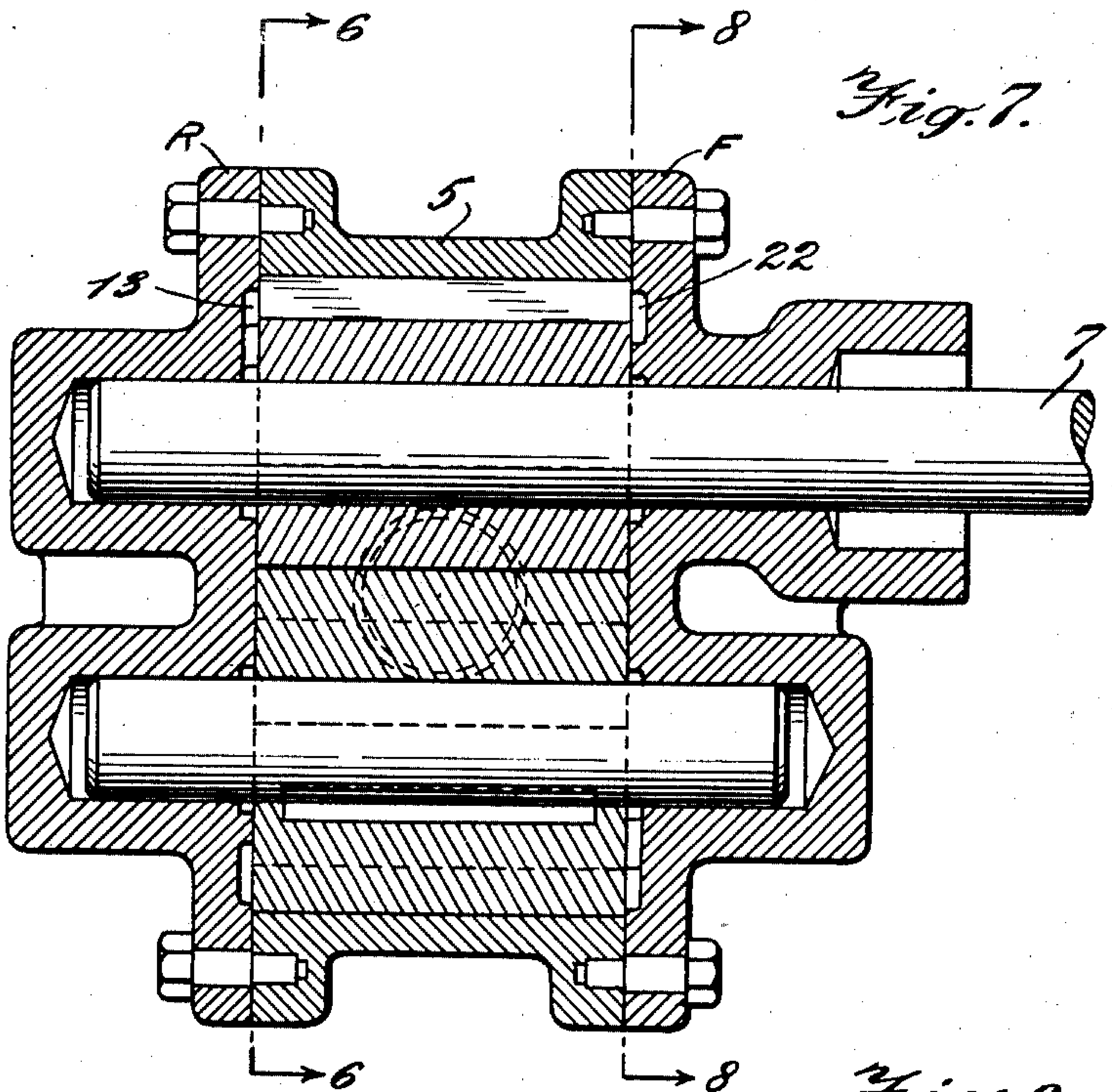


Fig. 8.

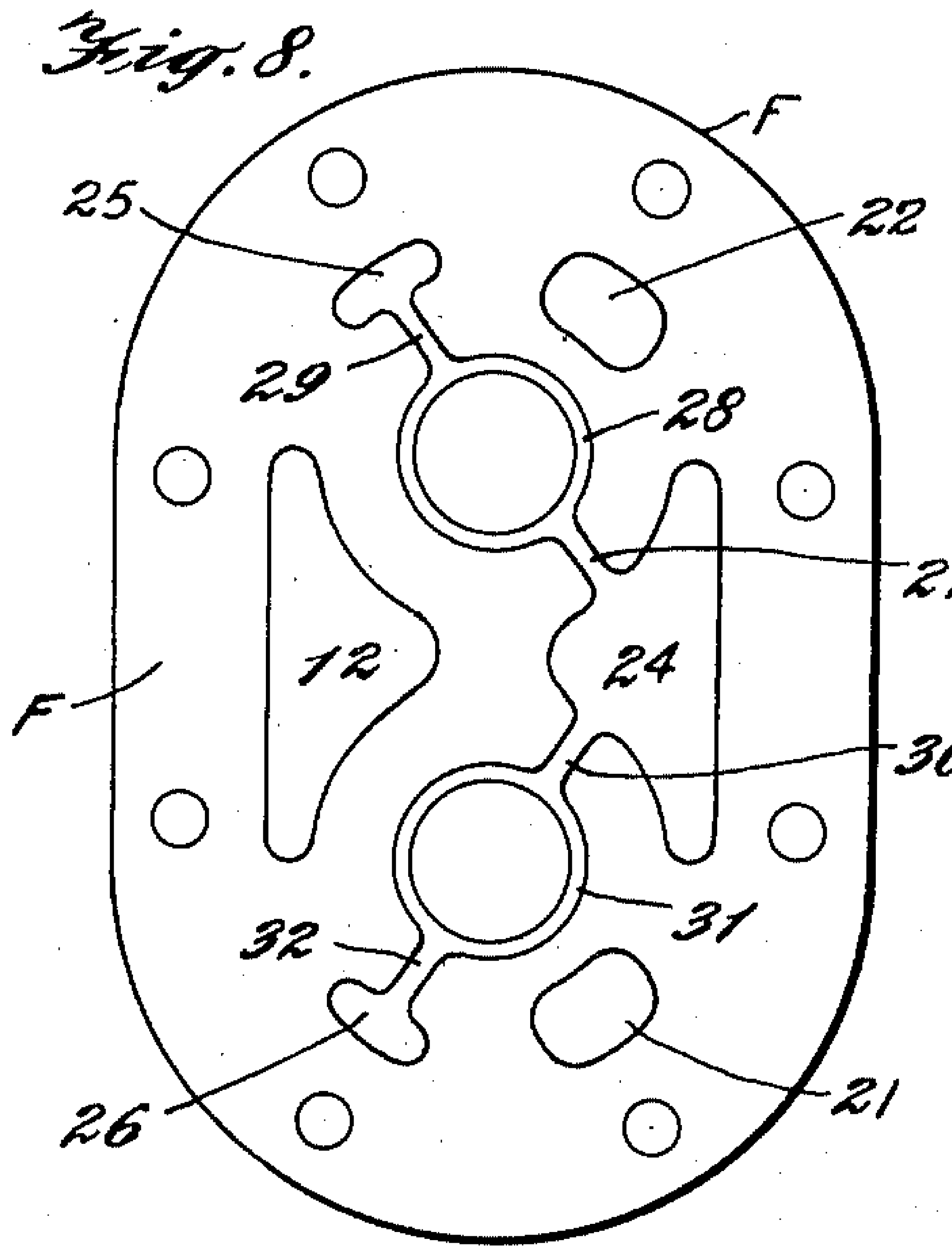
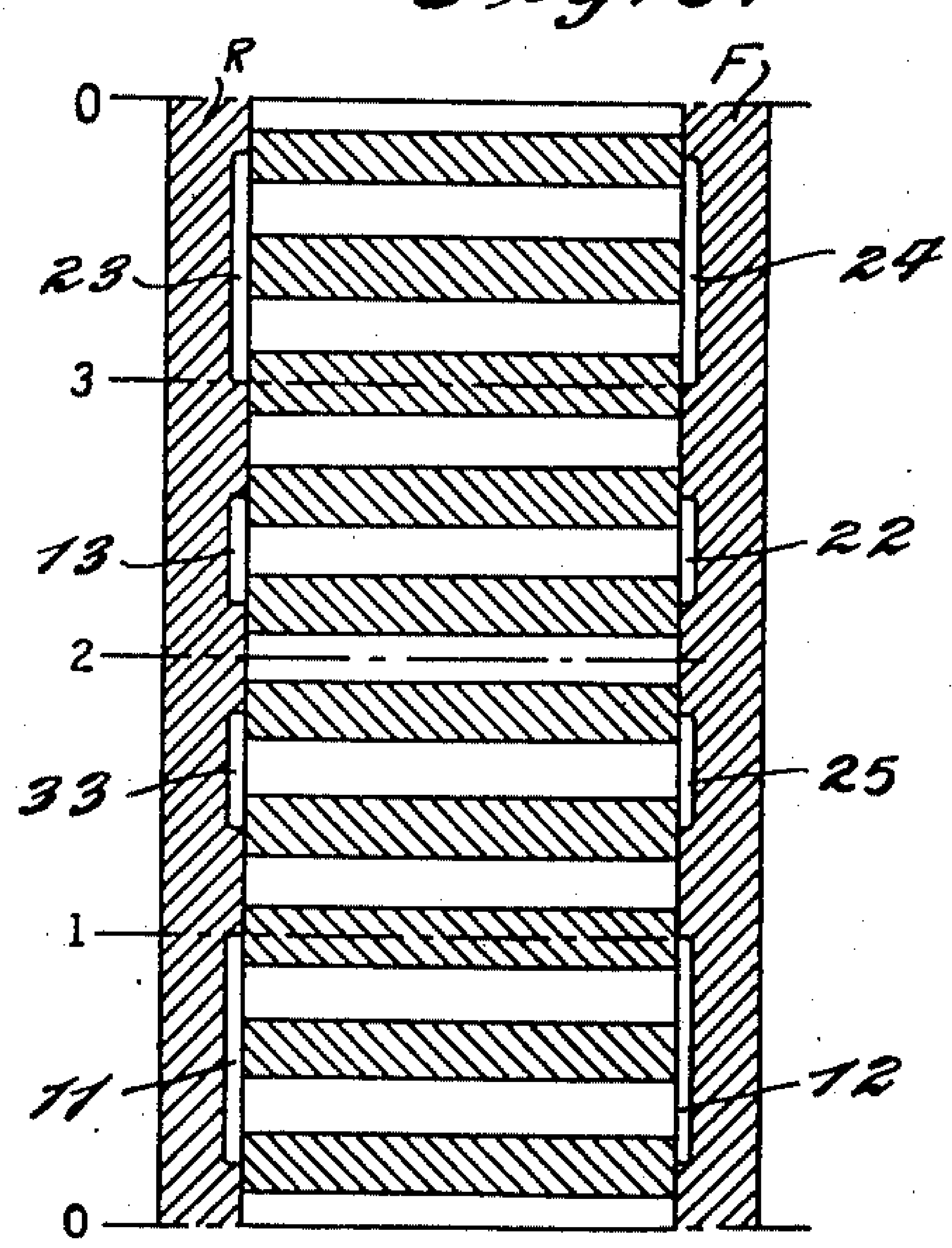


Fig. 9.



INVENTOR.
Gustave A. Ungar
BY
Lackenbach & Hirschman
ATTORNEYS

Feb. 6, 1951

G. A. UNGAR

2,541,010

GEAR PUMP OR MOTOR

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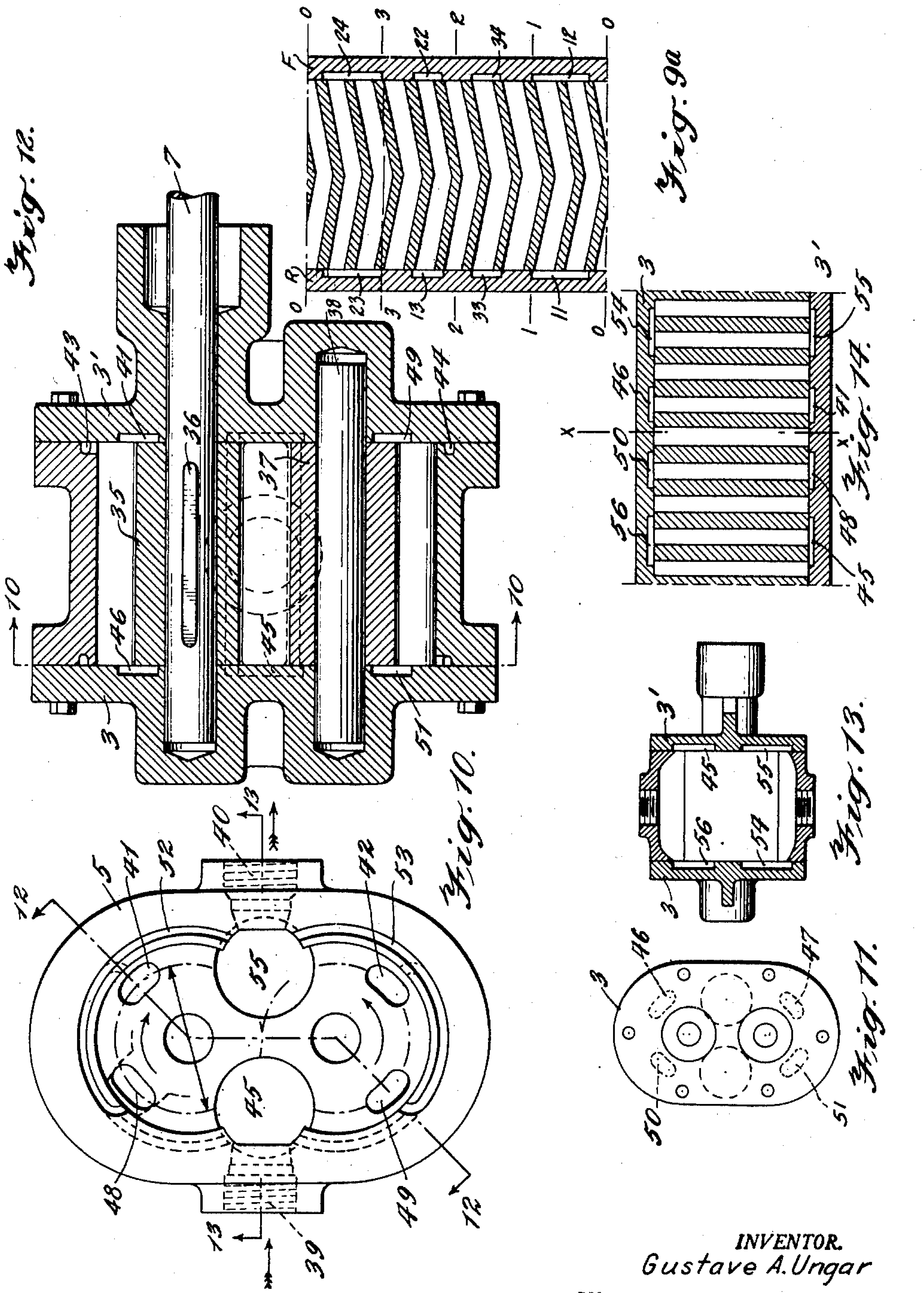

INVENTOR.
Gustave A. Ungar

BY

Lackenbach & Hirschman

ATTORNEYS

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GEAR PUMP OR MOTOR

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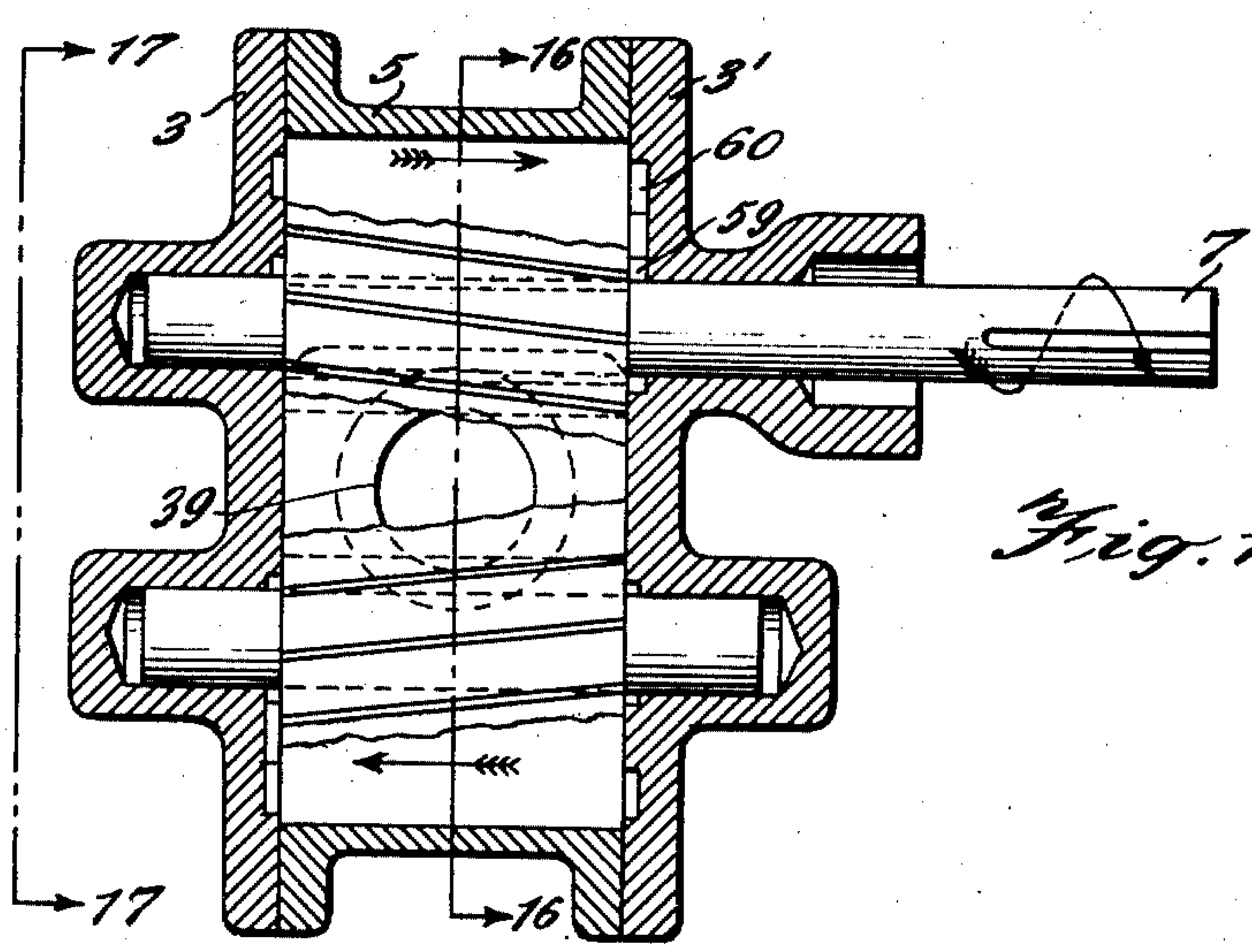

Fig. 15.

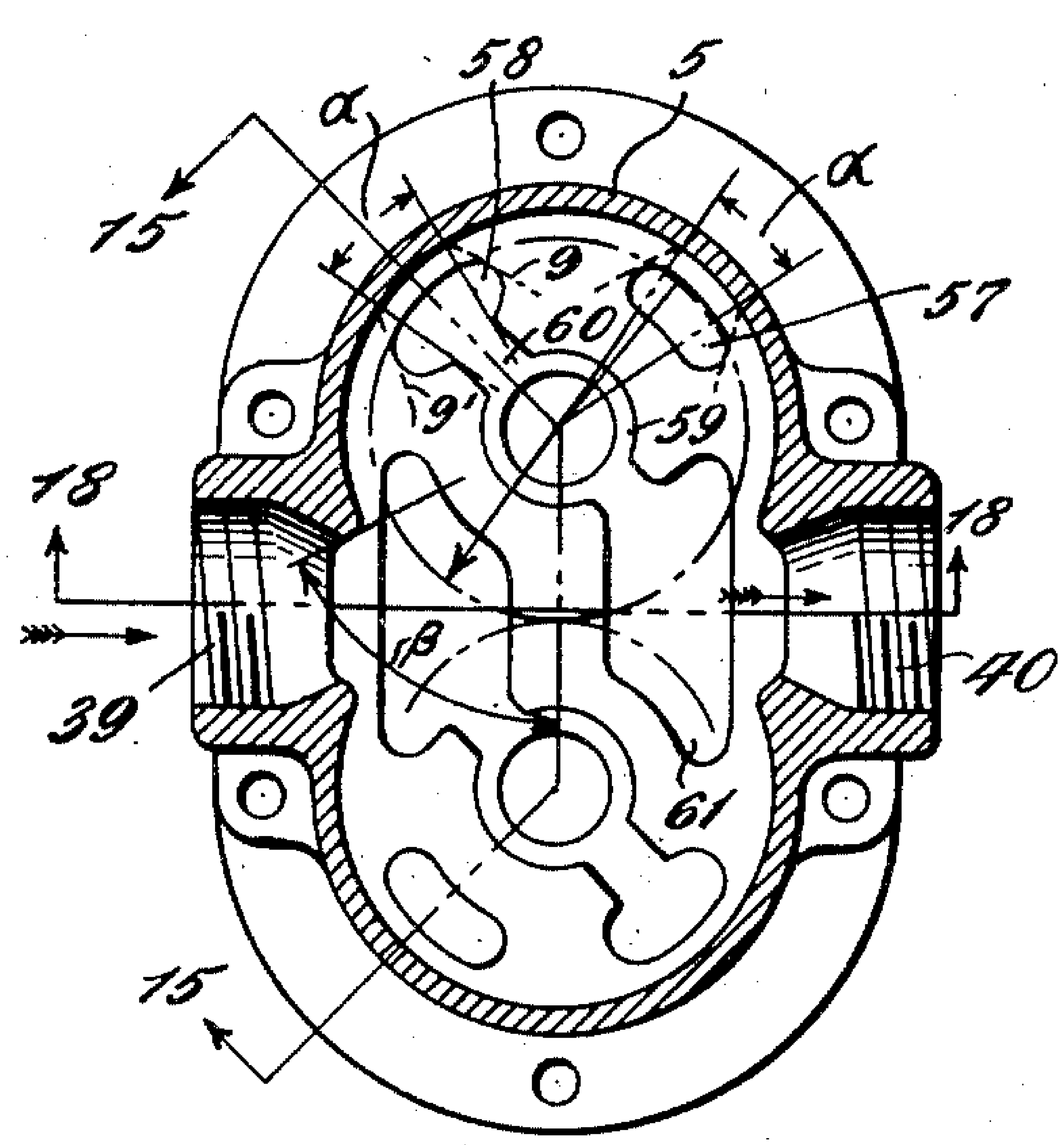

Fig. 16.

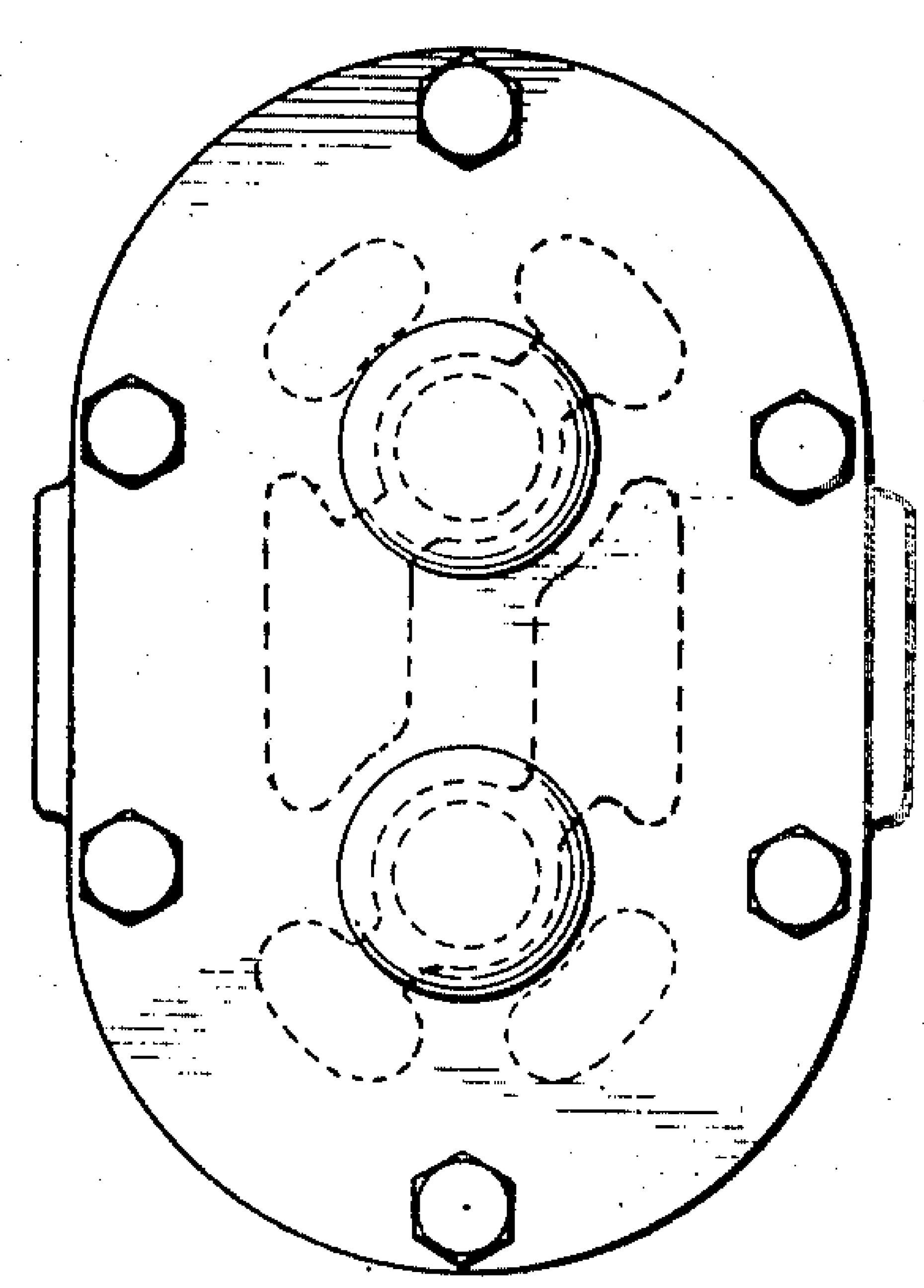

Fig. 17.

INVENTOR.
Gustave A. Ungar

BY Rattenbach & Hirschman

ATTORNEYS

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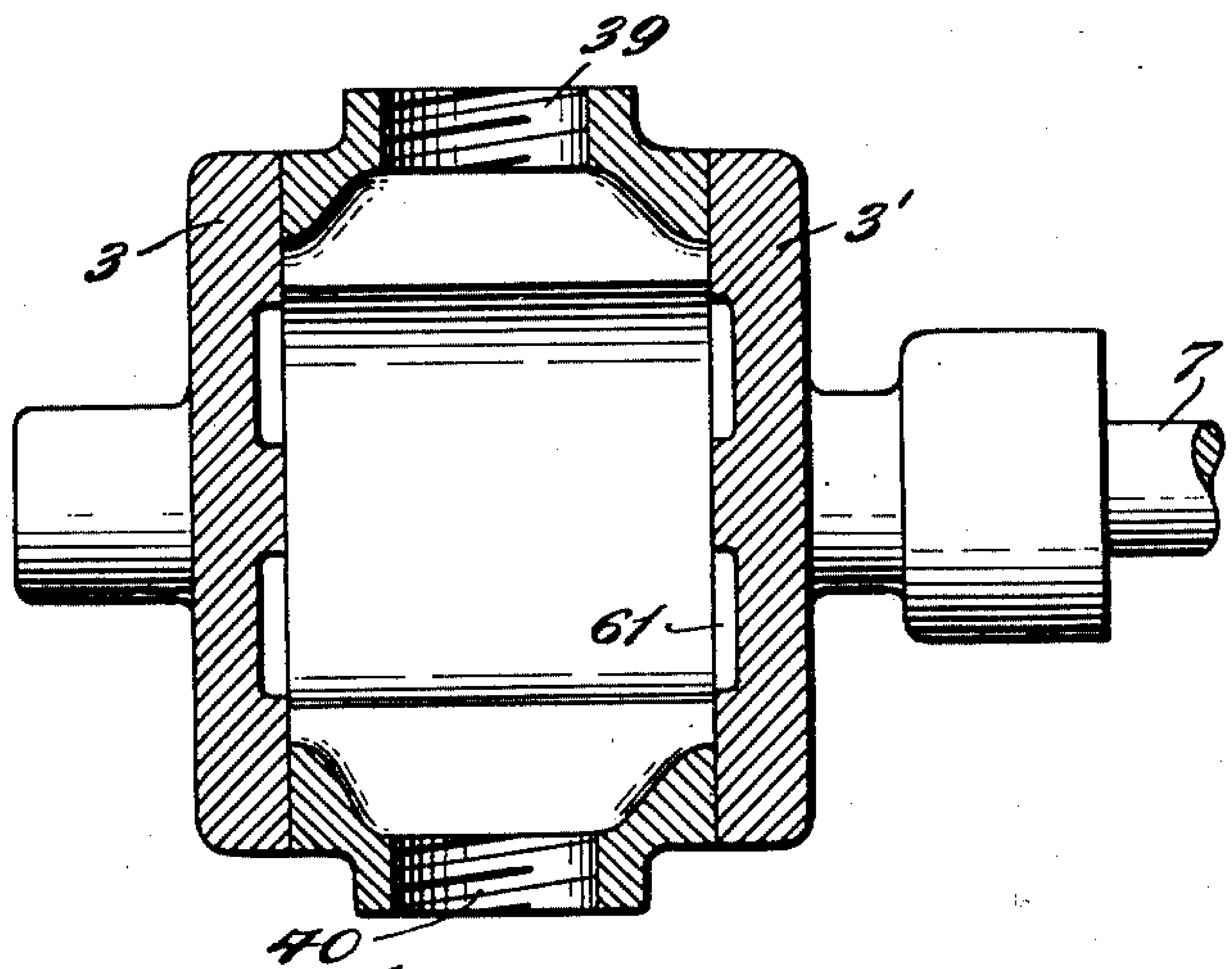

Fig. 18.

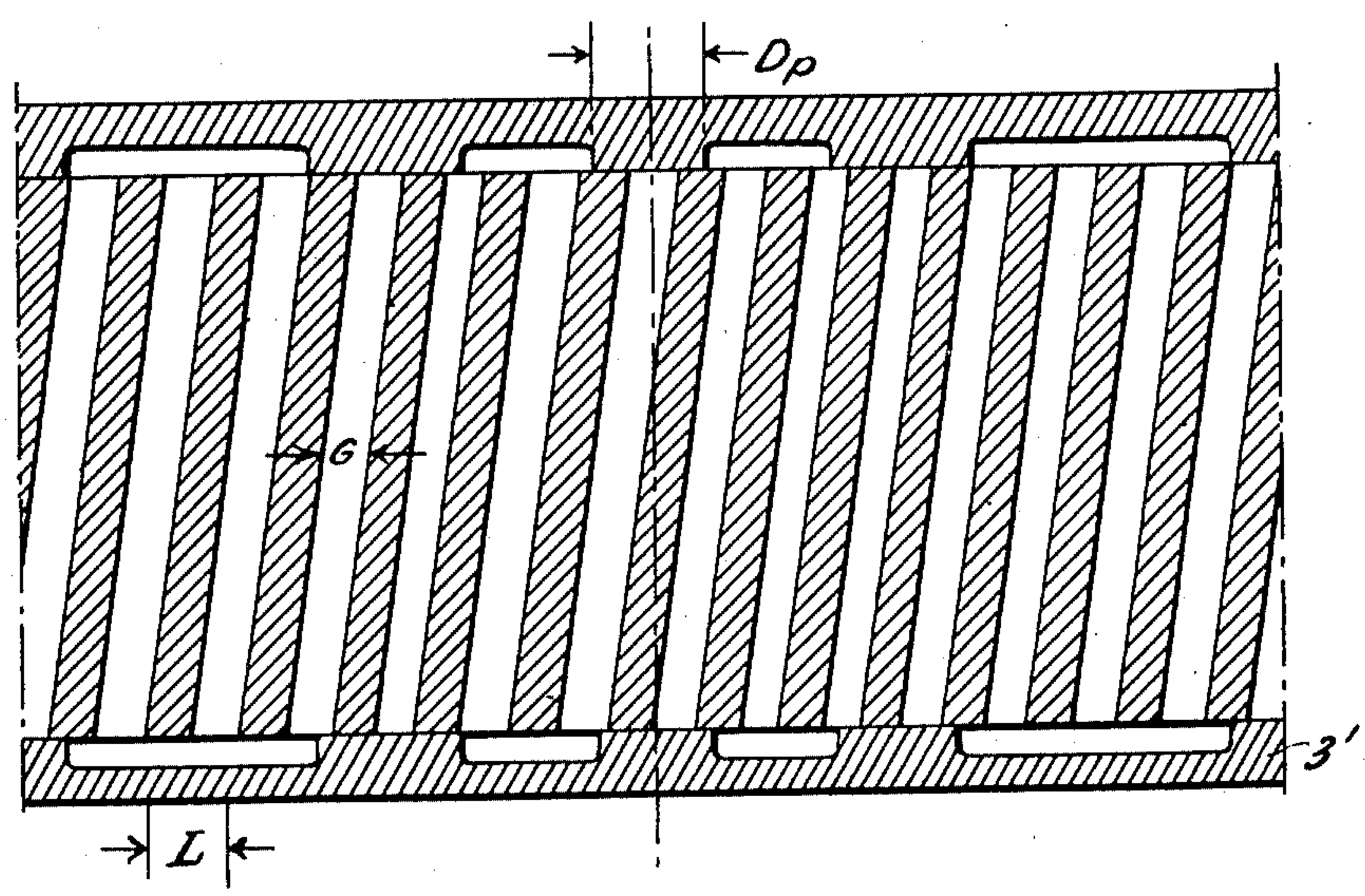

Fig. 19.

INVENTOR.
Gustave A. Ungar

BY
Lackenbach & Hirschman
ATTORNEYS

Patented Feb. 6, 1951

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UNITED STATES PATENT OFFICE

2,541,010

GEAR PUMP OR MOTOR

Gustave A. Ungar, New Rochelle, N. Y., assignor to Equi-Flow Inc., New York, N. Y., a corporation of New York

Application December 22, 1945, Serial No. 636,671

7 Claims. (Cl. 103—126)

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The invention relates to pumps or motors having cooperating rotors provided with a plurality of meshing lobes or teeth. While the invention is applicable broadly to structures of the class described, whether acting as a pump or as a motor, and whether using large lobes or small gear teeth and whether constructed as integral rotors or rotors constituted of a plurality of laminations, I shall hereinafter, for convenience of reference, refer to the structure as a gear pump, but this is not intended to so limit the invention. Also, whether the gear pump rotors are constituted of solid bodies or laminations, the invention is equally applicable to structures of the general class described.

The primary object of the invention is to generally improve gear pumps with reference to the radial balancing thereof. A more particular object of the invention is to provide such improvement in the radial balancing of gear type pumps by locating the balancing ports in the faces of the side walls of the housing or in the end covers, instead of in the barrels of the pump housing.

Previous efforts to improve the radial balancing of the gear type pumps have necessitated the provision of a complicated system of passages located inside the end covers and/or the housings, so as to connect the inlet and outlet chambers of the pump with the recesses or ports in the end walls or covers, such recesses or ports being intended to balance the inlet and outlet pressures respectively.

Among the more specific objects of the present invention are the following:

To provide connections for the pump ports with their balance ports by arranging suitable passages in the surfaces of the end cover or end wall;

To arrange the balance ports and the connecting passages for spur type and double helical type rotors in such a manner that no axial unbalance is possible;

To provide balance ports in the faces of the end covers or end walls of single helical type rotors for securing complete radial and axial balance of such rotors;

According to my present invention, all of the means for attaining the radial balancing of the gear pump are located in the end cover or end wall of the casing, of the pump.

Depending upon the type of gear used in the pump, the combination of radial balance ports provided in accordance with my present invention, may be used with ports compensating axial thrust, i. e., ports which act for obtaining axial balance of the pump.

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The accompanying drawings, Fig. 1–4, inclusive, demonstrate broadly the structure and function of the balance ports in the end cover faces when such balance ports are used to replace the conventional balance ports in the barrel of the casing.

In Figs. 5–9, inclusive, I show the application of the simplified radial balance arrangement of Figs. 1–4 with axially located balance ports to inherently axially balance a gear pump. The particular embodiment illustrated in Figs. 5–9, inclusive, for the application of such radial balance arrangements to spur gear pumps although it will be obvious to those skilled in the art that substantially the identical arrangement of ports could be used for double helical gear pumps.

In Fig. 9A I have illustrated a developed section of the pitch of an upper double helical gear of a pump construction embodying my invention.

In Figs. 10–14, inclusive, I have illustrated a modification of the arrangement of the connecting passages from the main ports to the balance ports in the side faces adjoining the rotors of an axially balanced gear pump of the spur type.

In Figs. 15–19, inclusive, I illustrate a pump with single helical gear, the pump being provided with both radial and axial hydraulic balance derived from the balance ports and connecting passages located in the faces of the end walls. In my U. S. Patent No. 2,338,065 of December 28, 1943, I have shown how axial balance of the balance hydraulic end thrust of the helical gear can be produced by means of balance ports located in the faces of the side walls. The axial thrust produced by single helical gears is analyzed on page 2 of my above-mentioned patent in lines 42 to 73, inclusive.

The present application is a continuation-in-part of my pending application, Serial No. 427,324, filed January 19, 1942, now abandoned.

Referring more particularly to the drawings, in the illustration of the simplified radial balance arrangement of Figs. 1–4, inclusive, Fig. 1 is a front sectional view of a structure in which the radial balance port of conventional configuration and disposition is shown in full lines and in dotted lines there is illustrated the new balance port located in accordance with my present invention in the end wall or end cover, the figure being a section taken along the line 1—1 of Fig. 2; Fig. 2 is a section along the line 2—2 of Fig. 1; Fig. 3 illustrates a section of a pump gear radially balanced by means of the balance port provided in the end wall in accordance with my present invention; and Fig. 4 is a section on the line 3—3 of Fig. 3;

In Figs. 5–9, inclusive, Fig. 5 is an external end view of the cover or end wall of a spur gear pump; Fig. 6 is a section on the line 6—6 of Fig. 7; Fig. 7 is an axial or longitudinal sectional elevation of the pump taken on the line 7—7 of Fig. 5; Fig. 8 is a section on the line 8—8 of Fig. 7; and Fig. 9 is a developed cylindrical section of the pump taken on the pitch circle of the gear in Figs. 5–8; Fig. 9A is a developed section of the pitch cylinder of an upper double helical gear; Fig. 10 is a side view on the line 10—10 of Fig. 12, into a spur gear pump casing showing the inner face of the end cover of the second embodiment of my invention, namely, the application of the arrangement of the connecting passages from the main ports to the balance ports in the spur type of gear pump; Fig. 11 is an external end view, on a reduced scale, of the front cover. Fig. 12 is an axial or longitudinal sectional end view of the pump taken on the line 12—12 of Fig. 10; Fig. 13 is a partly sectional bottom view of the pump casing taken along the line 13—13 of Fig. 10, on a reduced scale; and Fig. 14 is a developed cylindrical section of the same pump taken along the pitch circle of the upper gear; in Figs. 15–19, showing the third embodiment of my invention, Fig. 15 is a sectional elevation along the line 15—15 of Fig. 16, seen from the discharge side; Fig. 16 is a cross-section taken along the line 16—16 of Fig. 15, with the gear and shafts removed; Fig. 17 is an end view of an end cover seen from the line 17—17 of Fig. 15; Fig. 18 is a fragmentary bottom view of the pump casing on a reduced scale, the section being taken along the line 18—18 of Fig. 16; and Fig. 19 is a fragmentary developed section taken along the pitch circle of the upper gear in Fig. 16.

Referring more specifically to the various figures of the drawing, in Figs. 1–4, inclusive, the teeth 1, 1′ and 1′′ of the revolving gears pass in front of a balance port 2 disposed in the end wall or end cover 3. Each of the balance ports 2 is in fluid connection with either the inlet main port or with the outlet main port, thereby imparting either suction or discharge pressure to the appropriate tooth spaces which are in front of the ports. The radial thrust produced by the main ports is counterbalanced by port 2.

The balance port 4 in the housing barrel 5 extends over an angle α. Dot-dash lines 9, 9′, which are equidistant to the two curved profiles of gear 10, indicate the extreme boundary to which a substitute axial balance port could be extended without changing the radial balance established by angle α.

In Fig. 2, the dotted lines indicate such an axially located port 2 extending radially to the tip of the tooth. Figs. 3 and 4 show at 8 substitute axially located port extending radially to the root diameter and not quite to the outside diameter of the gear. The edges of balance port 8 are shown to touch the theoretical port boundary lines 9, 9′ at the tangent points 10′. Without changing the radial balance, these axially located ports can be extended below the root diameter toward the center of the gears as long as their angular extent does not transcend the theoretical port boundary limited by angle α.

Referring now more particularly to Figs. 5–9, inclusive, the balance ports or recesses are located in the inner faces of front cover F and rear cover R. The suction passage S in the pump

body is closed by end covers R and F which contain depressions 11 and 12 whose angular length determines how much of the rotor surface is radially loaded. To produce the desired loads in opposite directions, the counterbalance ports 13 and 14 in the rear cover are connected to ports 11 and 12 through groove 15, ring groove 16, groove 17 and groove 18, ring groove 19, and groove 20, respectively. The balance ports 21, and 22, respectively, are not provided with connecting grooves to depression 11, but their areas, in order to establish axial balance, are enlarged by extending them toward the gear centers until the following condition prevails:

Areas 13+17+16+15=area 22, and
Areas 14+20+19+18=area 21

In like manner, the pressure passage P in the pump body is axially enclosed by ports 23 and 24. The pressure balance ports 25 and 26 in the front cover F are suitably connected to port 24 by groove 27, ring groove 28, groove 29, groove 30, ring groove 31 and groove 32, respectively.

The areas of pressure balance ports 33 and 34 in the face of the rear cover R must fulfill the following requirements to establish axial balance:

Area (25+29+28+27)=33
Area (26+32+31+30)=34

If these conditions are fulfilled, the two rotors will be in radial as well as in perfect axial balance.

Figs. 10 to 14, inclusive, illustrate a modification of the arrangement of the connecting passages from the main ports to the balance ports in the side faces adjoining the rotors an axially balanced gear pump of the spur type. Here, these passages or grooves are located in the faces of the housing and closed by the end covers. It is evident that these connecting grooves could be arranged in the faces of the end covers on the area outside the outside diameters or the rotors and closed by the side faces of the pump casing. Arrangements of balance passages of this type in conjunction with radial balance ports provided in the form of recesses in the pump barrels are taught in my Patent No. 2,236,980, Figs. 14, 15, 18, 19, 20, 21 and 25.

Referring now to Figs. 10, 11, and 12, Fig. 10 shows the front of the barrel and the inner face of the pump cover 3′ with the front cover 3 removed. Gear 35 is keyed to the driving shaft 7 by key 36, while driven gear 37 revolves on a stationary shaft 38. The main supply port is designated as 39, and the main discharge port is 40. Substantially diametrically opposite to the main supply port 39 are suction balance ports 41 and 42 located in cover 3′. Such suction balance ports communicate by channels 43 and 44 with a recess 45 in cover 3′, said channels being closed by the cover. Corresponding suction balance ports 46, 47, are provided in the front cover 3. Diametrically opposite the main discharge port 40 are pressure balance ports 48 and 49 in the rear cover 3′. Pressure balance ports 50 and 51 in the front cover are connected by channels 52 and 53 in the front side of the casing with recess 54 in the front cover 3. Recesses 54 and 55 are provided at the ends of the discharge ports 40, recesses 56 and 45 at the ends of main suction port 39. The front cover 3, channels 52 and 53, recesses 54, 55 and 50 and 51 and ports 48 and 49 provide the radial pressure balance, while the rear cover

3′ with channels 43, 44, recesses 56 and 45 and ports 46, 47, 41 and 42 provide the suction balance.

Fig. 13 is a bottom view, partly in section, showing the upper parts with the rotors and shafts removed. The section is taken along the line 13—13 in Fig. 10. The depth and the arrangement of the recesses 54, 55, 56 and 45 may be taken from this illustration.

Fig. 14 is a developed cylindrical section taken at the pitch diameter of the upper gear. X is the center line; 56—45, 54—55, 46—41 and 50—48 represent the main inlet, main discharge, balance inlet, and balance discharge ports, respectively. The gap G between the two teeth, that is, the circumferential pitch less the angular top width of the teeth, is, of course, smaller than the angular distance between two ports to avoid a direct connection between consecutive ports, which are always under opposite pressure. The circumferential width of the ports in the end walls is the criterion of the radial rotor loads.

Referring now to Figs. 15–19, inclusive, a pump or motor having single helical gears is illustrated. The pump shown includes a barrel casing 5 having a main inlet port 39 and a main discharge port 40.

Single helical gears of this character each produce an axial thrust which work in opposite directions as indicated by the large arrows in Fig. 15. Provision for counterbalancing said thrusts are illustrated in Fig. 16 in which α is a port angle required for best radical balance, 9 and 9′ indicated in dotted lines being the theoretical limits of the balance ports 57 and 58 which are in tangential contact with the curves 9 and 9′ thereby producing the best balance. The axial thrust produced by the driving shaft 7 (Fig. 15) is directed toward the cover 3′. For compensating this thrust a central recess 59 surrounding the shaft 7 is formed in the end cover 3′, said recess, by means of slot 60, being under pressure. Another recess 61 to the extent of angle β is formed into cover 3′, such recess communicating with the slot 60 and over the axial balance port 59 with radial balance port 58.

Fig. 19 represents a developed circumferential section taken along the pitch circle of one of the gears. G again designates the gap between two consecutive teeth, while Dp defines the distance between the ports, L being the lead of the gear.

By the structure briefly described with respect to Figs. 15–19, both of the thrusts of the gears are balanced. Since the axial thrust produced by each of the gears are made in opposite direction as hereinabove pointed out, the central recesses opposite the lateral faces at the ends of the two gears must be under inverse pressure. This being the case, the pump or motor is reversible.

I have described herein above three different embodiments of my invention which is characterized by the provision of at least one recess receiving the main port pressure and located in an end wall of the gear pump casing. Such recess acts to impart balance pressure to as many teeth gaps at the same time as is required for best radial balance with or without the provision of means for securing axial balance. In other words, in its broadest aspect, my invention consists of the insertion of an enlargement into comparatively narrow connections between a pressure source and the tooth gaps, the enlargement being located substantially opposite the coordinated main port.

While I have described specific embodiments of my invention, it will be obvious to those skilled in the art that many changes in the particular arrangement and disposition of the parts may be made without departing from the invention; also, that my invention is equally applicable to pumps or motors of equivalent construction to those specifically illustrated and described.

Thus, my invention is obviously applicable to pumps or motors having mating rotors of the laminated type with one-directional displacement of the laminations, the rotors rotating as a single axially balanced unit floating between the end covers or end walls of the housing.

Similarly, the ports in accordance with my invention, may be provided in single helical or double helical gear pumps, or in the faces of the end covers in casings for laminated rotors having one or two directional displacement of the laminations, of such size and disposition as to secure radial and axial balance.

I claim:

1. A gear pump or motor comprising a casing including end covers providing casing end faces, a pair of intermeshing gears in said casing, a main supply port and a main discharge port in said casing, and means to secure radial balance of said pump or motor comprising balance ports in the end faces of the casing opposite the gear and faces, said balance ports being in fluid connection with the main ports which they are effective to balance, the fluid connections between the main and balance ports comprising passages in the end faces of the end covers and additional balance ports in the faces of the end covers opposite respectively to the first-named balance ports and equal in area to the first-named balance ports plus the areas of the connecting passages between the first-named balance ports and main ports whereby hydraulic axial balance of the gears is maintained, the fluid connections betwen the main and the first named balance ports being opened to the end faces of the gears.

2. A gear pump or motor as claimed in claim 1 in which the balanced ports are disposed inside a zone circumscribed by the outside circles of the gears.

3. A gear pump or motor comprising a casing including end covers providing casing end faces, a pair of intermeshing gears, in said casing, a main supply port and main discharge port in said casing and means to secure radial suction balance of said pump or motor comprising balance ports in one end face of the casing opposite the adjacent gear end faces, said balance ports being in fluid connection with the main supply port, the fluid connections between the main supply port and the balance ports in the end face of the casing comprising passages in the end faces of the adjacent end cover and additional balance ports in the face of the end cover opposite that which has the first-named balance ports and equal in area to the first-named balance ports plus the areas of the connecting passages between the first-named balance ports and the main supply port whereby hydraulic axial balance is maintained, the fluid connections between the main supply port and the first-named balance ports being opened to the end faces of the gears.

4. A gear pump or motor as claimed in claim 1 in which the balance ports are constituted of depressions in the casing end faces of the end covers.

5. A gear pump or motor as claimed in claim 1

in which the angular extent of the first named balance ports is determined by providing a port in the casing exposing a sufficient number of tooth pockets to the hydraulic pressure exerted in opposite direction on the tooth pockets exposed in the main port so as to provide radial balance, the outline of the first named balance ports being circumscribed by curves identical with tooth profiles starting at the outside diameters of the gears at points determinative of the circumferential width of substitute radial balance ports in the housing barrels.

6. A gear pump or motor comprising intermeshing gears, a casing surrounding said gears, said casing including covers providing casing end faces and including main supply and discharge ports leading to said gears, fluid in said main ports producing radial thrust on said gears, balance means for counteracting said radial thrust, said means including ports for radial balance arranged in the end faces of said casing, each of said ports being in fluid connection with one of said main ports, the fluid connections between the main and balance ports comprising passages in the end faces of the end covers and additional balance ports in the faces of the end covers opposite respectively to the first-named balance ports, and equal in area to the first-named balance ports plus the areas of the connecting passages between the first-named balance ports and the main ports whereby hydraulic axial balance of the gears is maintained, the fluid connections between the main ports and the first mentioned balance ports being open to the end faces of the gears.

7. In a gear pump or motor comprising a casing, said casing including end covers providing

casing end faces and including main and intake and outlet ports, a pair of gears, disposed in meshing engagement between said main ports, the side faces of said gears being adjacent to said casing end faces, said casing end faces having recesses located opposite a ring zone including the teeth of said gears, fluid connections between the main ports and said recesses, said recesses being substantially diametrically opposite said main port, the circumferential width of each of said recesses being adapted to produce the required area of balance on the adjacent gear, said fluid connections comprising passageways in the casing end faces of the end covers, said passageways being open to the end faces of the gears and additional recesses in the faces of the end covers opposite respectively to the first named recesses and equal in area to said first named recesses plus the areas of said passageways.

GUSTAVE A. UNGAR.

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