

May 16, 1944.

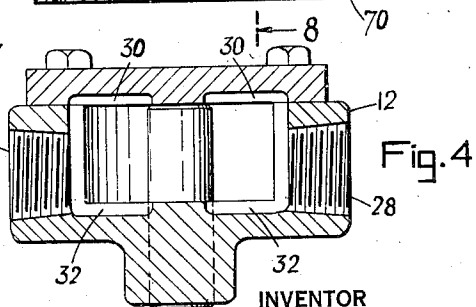
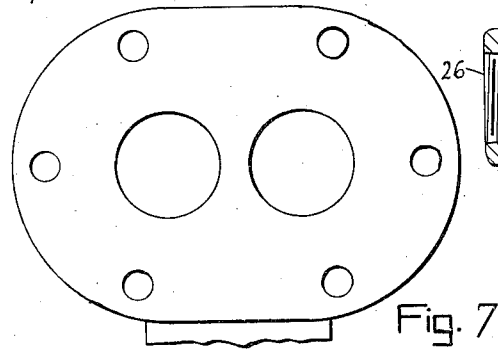
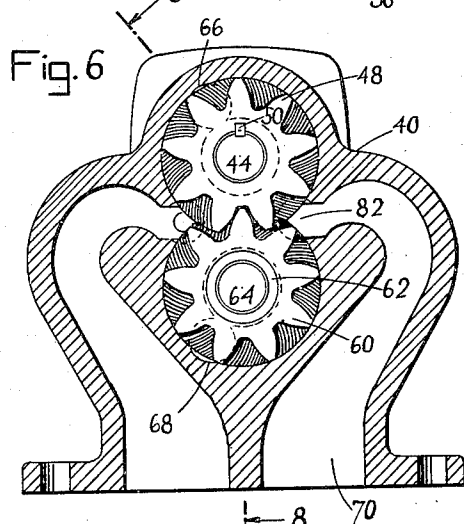
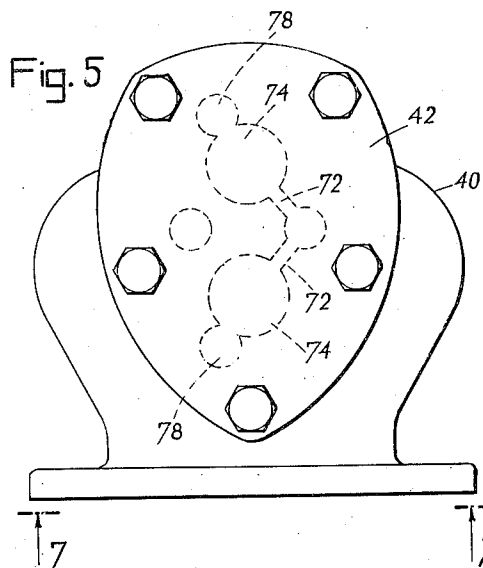
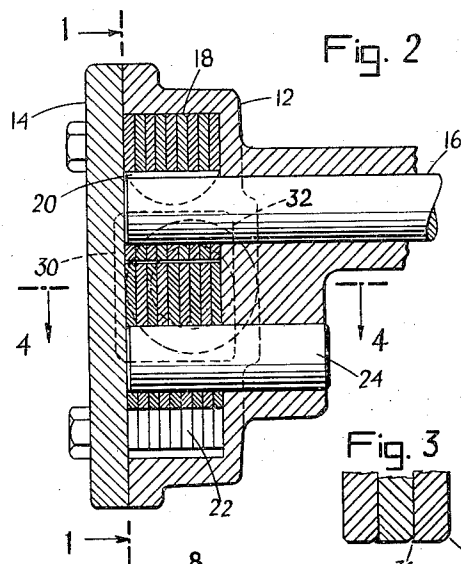
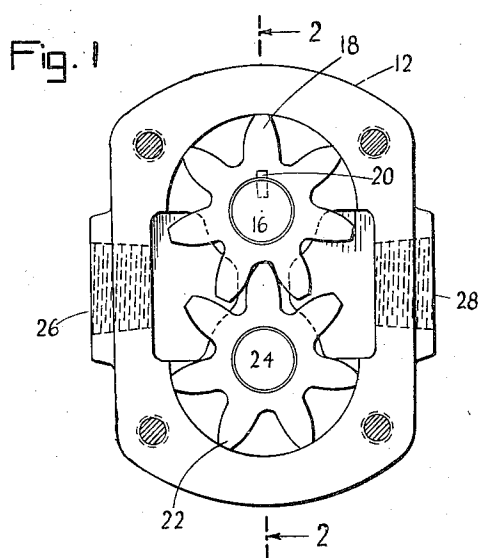
G. A. UNGAR ET AL

2,349,022

LAMINATED GEAR PUMP

Filed March 28, 1941

3 Sheets-Sheet 1



INVENTOR
GUSTAVE A. UNGAR
JOSEPH F. KELLER
BY *James H. Thompson*
ATTORNEYS

May 16, 1944.

G. A. UNGAR ET AL

2,349,022

LAMINATED GEAR PUMP

Filed March 28, 1941

3 Sheets-Sheet 3

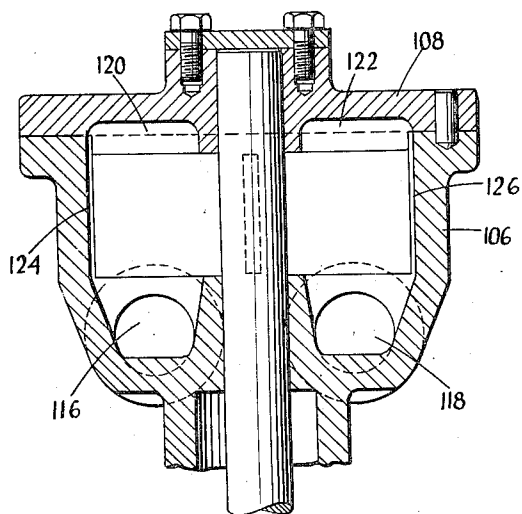
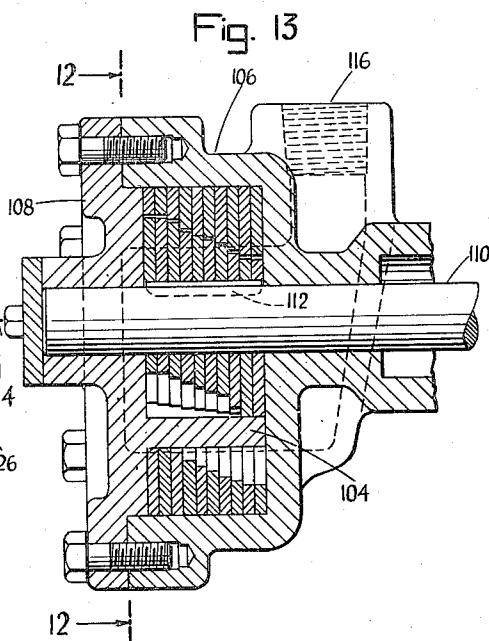
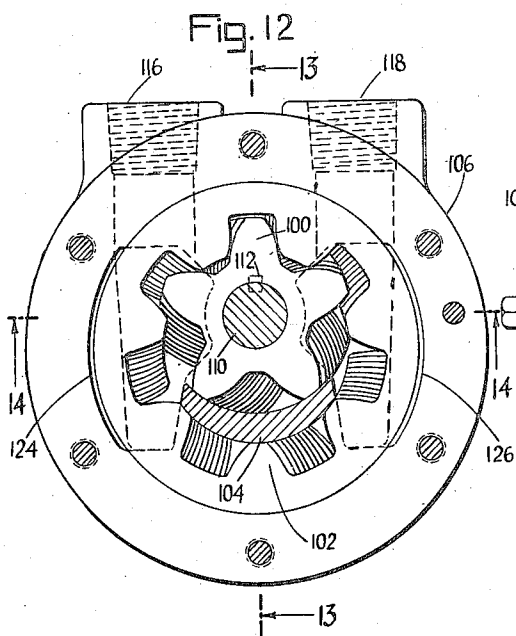


Fig. 14

INVENTOR

GUSTAVE A. UNGAR
JOSEPH F. KELLER

James F. Trautman
ATTORNEYS

UNITED STATES PATENT OFFICE

2,349,022

LAMINATED GEAR PUMP

Gustave A. Ungar, New Rochelle, and Joseph F. Keller, New York, N. Y., assignors, by direct and mesne assignments, to Equi-Flow Inc., New York, N. Y., a corporation of New York

Application March 28, 1941, Serial No. 385,618

22 Claims. (Cl. 103—126)

This invention relates to pumps, and more particularly to gear pumps.

The primary object of our invention is to generally improve gear pumps. A more particular object is to cheapen the manufacture of gears for such pumps, this preferably being done by building up the gears out of stamped laminations, thus eliminating the need for cutting the gear teeth.

A further object is to dispense with the need for precision manufacture, and to avoid jamming or locking of the laminated gears even though the teeth have not been finish ground to exact dimension. For this purpose the laminations of only the driving gear are keyed, while the driven laminations are left unkeyed and at least slightly rotatable relative to one another in order to automatically and freely adjust themselves to the laminations of the driving gear.

Still another object centers about the need for holding the laminations compressed together in face to face relation. If they are clamped solely at the hub, they may tend to spread at the teeth. To clamp the gears at the teeth would be expensive, and with small gears would be impractical. In accordance with an important feature and object of our invention, the laminations are held together by fluid pressure, and are still capable to move axially away from each other so as to prevent possible interference with the adjacent laminations which are in mesh. A very slight surface wear on the side faces of the teeth can, therefore, take place during a running-in period until the required operating clearances have been established, and there is no longer any necessity for axial yielding, excepting to permit passage of slight impurities.

Still another object of our invention is to obtain most of the benefits of helical gearing without the usual expense of making helical teeth, and without the disadvantage of axial thrust, nor the cost of double helical gears. For this purpose the successive laminations are stepped or rotatably displaced to form an approximate helical gear. There is no axial thrust because the individual laminations are thin spur gears. The slight angular displacement of the laminations also eliminates trapping between the meshing teeth of the individual pairs of laminations since the liquid trapped is enclosed between the meshing teeth of one pair of laminations and is in communication with similar spaces of trapped liquid in the adjacent pairs of lamination until the spaces finally communicate either with the in-

take or the discharge port. As long as the angular displacement of the end laminations is not such as to permit a short circuit between the intake and the discharge ports, there will be no danger of leakage. Since there is no trapping, there is consequently no necessity for artificial leakage to avoid the hydraulic shock which is a consequence of trapping. This method of rotatably displacing laminations may also be used to obtain rotors for screw pumps. The features of the invention are applicable to internal as well as external gear pumps.

To the accomplishment of the foregoing general and such other more specific objects as will hereinafter appear, our invention consists in the gear pump elements and their relation one to the other as hereinafter are more particularly described in the specification and sought to be defined in the claims. The specification is accompanied by drawings, in which:

Fig. 1 is a section through a spur gear pump taken in the plane of the line 1—1 of Fig. 2;

Fig. 2 is a section through the spur gear pump taken in the plane of the line 2—2 of Fig. 1;

Fig. 3 is an enlarged fragmentary section through a part of a gear tooth, and is explanatory of a detail;

Fig. 4 is a section through the housing taken approximately in the plane of the line 4—4 of Fig. 2, with the gears removed;

Fig. 5 is a front elevation of a modification using gears having rotatably displaced laminations;

Fig. 6 is a section taken approximately in the plane of the line 6—6 of Fig. 8;

Fig. 7 is a bottom view of the base of the pump;

Fig. 8 is a transverse section taken approximately in the plane of the line 8—8 of Fig. 6;

Fig. 9 is a sectional development at a radial balance port, drawn to enlarged scale, and shows the stepping of the gear teeth;

Fig. 10 is an enlarged fragmentary section through a gear tooth;

Fig. 11 is a section through a modification of the invention;

Fig. 12 shows the invention applied to an internal gear pump, and is a section taken approximately in the plane of the line 12—12 of Fig. 13;

Fig. 13 is a section taken approximately in the plane of the line 13—13 of Fig. 12; and

Fig. 14 is a horizontal section through the casing, taken approximately in the plane of the line 14—14 of Fig. 12, with the rotors removed.

Referring to the drawings, and more particularly to Figs. 1, 2, and 4, the pump there shown comprises a casing 12 closed by a cover plate 14 and rotatably receiving a driving shaft 16. The driving gear 18 comprises stacked laminations which are keyed to shaft 16 by means of key 20. The driven gear 22 is similarly made of stacked laminations, but these laminations are preferably freely rotatable on their support shaft 24. Thus the individual laminations of gear 22 are free to adjust themselves for proper mesh with the laminations of the driving gear 18, and this dispenses with the need for precision manufacture or close tolerances. In fact, the gear teeth need not be finish-machined nor ground, and instead may be stamped out of sheet metal stock directly to proper configuration and dimension.

The pump housing is provided with main pumping ports 26 and 28. The cover plate 14 is recessed or hollowed at 30 (Fig. 4), thus providing end ports which communicate with the pumping ports and open onto the end faces of the gears. The main casing body 12 is similarly recessed at 32 (Fig. 4), thereby forming ports at the opposite ends of the gears. The pump is symmetrical and reversible but whichever port acts as a pressure port is connected to end ports located at opposite sides of the gears, and the laminations are thereby squeezed together by the hydraulic pressure of the fluid being pumped. In other words, the pressure developed by the pump itself is used to hold the gear laminations in desired face to face contact.

The laminations, if not treated further after being stamped from sheet metal in a suitable die, will be rounded at one edge, as indicated at 34 (Fig. 3), and feathered at the opposite edge, as indicated at 36 (Fig. 3). The feathering at 36 is invariably smaller than the rounding of the metal at 34, and the laminations may therefore be nested together properly as shown in the drawings. Moreover, there is some clearance left because the feathered edge is smaller than the rounded edge and this permits the desired slight self-adjustment of one driven lamination relative to another for best mesh with the driving laminations.

The laminations may, of course, be treated to remove the feathered edges, as will be subsequently described, this being desirable when rotatably displacing the laminations to form approximately helical teeth, but the point here made is that when using simple spur gear teeth it is not even necessary to further treat the laminations to eliminate the feathered edges.

Referring now to Figs. 5-8 of the drawings, the pump there shown comprises a main housing 40 closed by means of a cover plate 42. The driving shaft is indicated at 44 and this passes into the pump casing through a suitable seal, the mechanism of which is generally designated 46.

The driving gear 48 is built up of laminations, these being keyed to shaft 44 by means of a key 50. The driving gear 48 differs from that previously described, in that the successive laminations are rotatably displaced or stepped relative to one another in order to form approximately helical teeth. This stepping of the successive laminations is clearly shown in Fig. 9, and it should be observed that the amount of rotatable adjustment is kept less than the width of a tooth edge. Thus, although the tooth edge 52 is displaced from the tooth edge 54, there is no space for leakage therebetween because the amount of dis-

placement is less than the width of the tooth edge, leaving an overlap which provides a continuous seal from one end of the gear to the other.

The driven gear 60 is similarly made up of laminations which are in stepped relation, but this stepped relation is maintained solely by reason of the engagement of the driven gear with the driving gear, for the driven laminations as before are unkeyed and relatively rotatable.

For convenience in handling the driven laminations, they may, if desired, be carried loosely or rotatably on a sleeve. This is most clearly shown in Figs. 6 and 8 in which it will be seen that the laminations are disposed on a sleeve 62 which, in turn, is received over a support shaft 64. The ends of sleeve 62 may, if desired, be slightly upset, thus anchoring the laminations on the sleeve for purposes of handling. The sleeve 62 may, if desired, be rotatable on shaft 64 in which case the relative movement of the laminations on the sleeve may, for the most part, be limited to any slight self-adjustment needed.

The present pump is somewhat more elaborate than that previously described in being provided with radial balance ports indicated at 66 and 68 in Figs. 6 and 8. The present pump is not intended to be reversible, and the radial balance ports are connected to the pressure pumping port 70, as by means of the connections indicated at 72 in Fig. 5.

End ports are also provided to hold the laminations together under hydraulic pressure. The end ports comprise relatively large circular recesses (74 in Fig. 5) formed concentrically with the gears, such recesses being provided at both ends of the gears, as is clearly shown in Fig. 8. The recesses 74 are formed in the end cap 42, while the corresponding recesses 76 are formed in the pump body 40. These recesses are connected to the radial balance ports by means of additional end ports 78 and 80, and are connected with the pumping port by means of the connections 72 previously referred to. Thus the end ports and the radial balance ports are all under pressure, the action of the end ports being to compress the laminations together, and the action of the radial balance ports being to counteract the radial pressure at the pumping port 82, the radial balance ports 66 and 68 being located approximately diametrically opposite the pumping port 82.

In reversible pumps it is essential to provide additional radial balance ports opposite the suction pumping port, but that refinement is dispensed with in the present pump and this, in turn, simplifies the problem of providing extensive pressure ports at the ends of the gears for holding the laminations together. In the specific pump here shown it would not be feasible to provide radial balance ports opposite both pumping ports because of the small number of teeth on the gears, but with gears having a larger number of teeth it would be feasible to do so. In Fig. 8 it will be seen that the end area of the shaft 44 is exposed to pressure. This tends to urge the shaft toward the right as viewed in Fig. 8, and this excess pressure is used to keep the sealing surfaces at the seal 46 in sealing contact. The rotor assembly with its key is preferably slidable on the shaft and the key may have upturned ends as shown.

When dealing with helically-stepped laminations, the feathered edges of the laminations are preferably eliminated. This is most simply done by feeding the stamped blanks into a second op-

eration die which functions essentially as a coining die and forces the feathered edge back into the plane of the lamination. This also eliminates the curvature at the opposite edge. The edges of the laminations then have a configuration like that shown in Fig. 10, there being no feathered edge at 84, and no curvature at 86.

This additional operation to eliminate the feathered edge on the laminations may, of course, be employed even when dealing with a spur gear pump of the type shown in Figs. 1 and 2. With spur gears the slight residual crevice is of no great disadvantage and, in fact, has the advantage of preventing trapping of liquid in the teeth of the gears. This feature of eliminating trapping is important and is desirable even with solid gears. But there is no such trapping of liquid with helical gears, and the crevices would merely produce undesirable leakage.

Fig. 11 is a fragmentary section taken through the shafts, as in Fig. 8, but illustrates a modification characterized by two features. The pump, contrary to the others described in the specification, is a relatively large one and is intended to handle particularly heavy or viscous liquids. In that case the gears are built up of laminations 90 which are relatively thick and may be individually cast and machined, instead of being stamped from sheet metal. In the finishing of these laminations the side faces of the gear teeth are ground away slightly to provide clearances 92 between the laminations, these being intended to prevent excessive friction and heating. Of course, the spaces in Fig. 11 are exaggerated, and in practice the amount ground away at the sides of the teeth would be a matter of only one-half to five one-thousandths of an inch. Thin spacing washers may be used for the same purpose.

The illustration in Fig. 11 also shows the provision of bearing surfaces at 94, which surfaces are localized to the hub portion only of the gear or rotor. In the present case, this localization of the bearing surface may be obtained as a result of the grinding away of the sides of the gear laminations as previously described or, in other cases, may be obtained by recessing the wall of the casing around the annular parts 94 as is indicated at 96, or by providing a slight projection at 94.

The invention is applicable to internal as well as external gear pumps, and such a pump is illustrated in Figs. 12, 13, and 14. Referring to those figures, the driving gear 100 in this particular case has five teeth and meshes with a driven gear 102 having seven teeth. The gears are separated at the bottom by a stationary crescent 104 forming a part of the gear casing. The casing is made up of a main body 106, and a head or cover 108, and in the present case the crescent 104 is formed integrally with the cover 108.

The driving gear 100 is built up of relatively thin laminations keyed to the driving shaft 110 as indicated at 112. The driven gear is similarly built up of laminations, these being rotatably received within the cylindrical casing. The driven laminations are unkeyed and are free to adjust themselves rotatably for proper mesh with the driving laminations.

One very important advantage of using laminated gears in the present pump is the possibility of providing approximately helical teeth. Helical teeth have rarely been used for internal gear pumps because of the extreme difficulty and high cost of providing the internal gear with helical teeth. When using laminated gears as here disclosed, however, the stepped relationship of the laminations is obtained fully as readily as is the

case with external gear teeth. The driving gear is similar to those previously described, and the displacement of the driven laminations takes place automatically by reason of their free mesh with the driving laminations.

The pump body 106 is provided with pumping ports 116 and 118, the pump being symmetrical and reversible. These lead to one side of the gears as is most clearly shown in Fig. 14. Ports 120 and 122 are provided at the opposite ends of the gears and are connected respectively to ports 116 and 118 by means of passages 124 and 126. As in the case of the pumps previously described, the ports are enlarged in area at the ends of the gears in order to provide equal opposed hydraulic pressures on the gear laminations. This fluid pressure is obtained at whichever side of the pump is being used as the discharge side.

It is believed that the construction and operation, as well as the many advantages of my improved laminated gear pump will be apparent from the foregoing detailed description. It will be understood that the features of the invention described herein are applicable to either spur gears, or approximately helical gears, and even screw pumps, the screw rotor being obtained by displacing laminations exactly as heretofore described for helical gears. The loose laminations of the driven gear may, if desired, be carried on a sleeve or tube for convenience in handling. This might also be done with a driving gear, but that would be wasteful because the driving gear laminations are anyway keyed to the driving shaft and may be handled with the shaft as a unit. When the term "keyed" is used in this description and in the appended claims, it will be understood that the term is meant to include other methods of fixing or securing the laminations to the shaft. The invention is applicable to internal as well as external gear pumps, and the internal gear pumps may have either spur teeth or approximately helical teeth, as desired.

The use of unkeyed driven laminations dispenses with the need for precision manufacture and avoids possible jamming of the gears. The use of fluid pressure to hold the laminations together is of great practical convenience because it eliminates the need for special mechanical means for that purpose which, in many cases, would not be feasible or would be far too costly.

Moreover, the use of fluid pressure to hold the laminations together makes the same axially yieldable a slight amount. This permitted axial "breathing" between the laminations is particularly important until the gears have been properly run-in, because it provides relative clearance of the laminations of the two gears as they pass one another.

The circumferential displacement of the laminations in the approximate helical type gears has many advantages such as improved mechanical meshing with less noise; a substantially constant rate of delivery from the pump, that is, from all of the laminations, despite the variations in the delivery at each single lamination; and the elimination of trapping of fluid between the teeth of the individual laminations, there being communication from one to the next and ultimately to the pumping port. Of course, the total angular displacement of the end laminations must be so limited as to prevent a short circuit from the inlet to the outlet port, and further the displacement of the individual lami-

nations must not be so great as to permit leakage around the edges of the tooth lands.

The circumferentially displaced laminations are axially balanced. All laminations, except the two outside ones, are axial balanced because the differential surfaces exposed to fluid pressure are always the same. The outside laminations exposed to the end port areas are substantially the same on both sides and are considerably larger than the differentially exposed inside surfaces of the end laminations. Therefore the outside laminations are pressed inwardly with variable but substantially equal pressures. The rotor assembly as a whole consequently remains axially balanced.

It has been mentioned that the laminations are yieldably held together by the fluid pressure. Where the pressure available is comparatively slight as, for example, in vacuum pumps, suitable spring means may be used to yieldably hold the laminations together.

The invention may be applied to fluids of a liquid or gaseous nature, and may be applied to motors as well as pumps.

The laminations may be used as struck from sheet metal or may be additionally treated to remove any feathered edge. Residual crevice between laminations at their edges may be usefully employed, in the case of spur gears, to avoid trapping of liquid between teeth. In such case the laminations are preferably stacked in a common direction relative to the direction in which they were stamped from sheet metal.

It will be apparent that while we have shown and described our invention in several preferred forms, many changes and modifications may be made in the structures disclosed without departing from the spirit of the invention as sought to be defined in the following claims.

We claim:

1. A gear pump comprising a casing, fluid inlet and discharge ports in said casing, a driving shaft, a driving gear built up of laminations keyed to said driving shaft but being axially free for slight axial movement, a driven gear meshing with said driving gear, said driven gear being built up of laminations rotatively carried in said casing, each driven lamination meshing with and having substantially the same thickness as a specific corresponding driving lamination, said driven laminations being at least slightly self-adjustably rotatable relative to one another, for best mesh with their respective mating driving laminations.

2. A gear pump comprising a casing, a driving shaft, driving and driven gears, said gears being built up of laminations, the laminations of the driving gear being so keyed to said driving shaft as to be non-rotatable but axially movable on said shaft, the laminations of said driven gear being axially movable relative to one another, pumping ports in said casing, and end ports in said casing at the opposite ends of the laminated gears and connected to the pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face relation by the hydraulic pressure of the fluid being pumped.

3. A gear pump comprising a casing, a driving shaft, a driving gear built up of laminations keyed to said driving shaft, a gear meshing with said driving gear, said gear being built up of laminations at least slightly self-adjustably rotatable relative to one another, for best mesh with their respective driving gear laminations, inlet

and discharge ports in said casing, and end ports in the casing at the opposite ends of the meshing gears and connected to the pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face relation by the hydraulic pressure of the fluid being pumped.

4. A gear pump comprising a casing, a driving shaft, a driving gear built up of relatively thin stamped laminations keyed to said driving shaft, a driven gear meshing with said driving gear, said driven gear being built up of relatively thin stamped laminations rotatively carried in said casing, said driven laminations being at least slightly self-adjustably rotatable relative to one another, for best mesh with the driving laminations, inlet and discharge ports in said casing, and end ports in the casing at the opposite ends of the driving and driven gears and connected to the pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face relation by the hydraulic pressure of the fluid being pumped.

5. A gear pump comprising a casing, fluid inlet and discharge ports in said casing, a driving shaft, intermeshing gears built up of relatively thin stamped metallic laminations axially yieldable with respect to each other, one of said intermeshing gears being secured to said driving shaft, the laminations of said gears all being faced in the same direction relative to the direction in which they were stamped from sheet metal, whereby any feathered edge produced on one lamination during the stamping operation is accommodated by the rounded edge of the next lamination, the sheared edges of said metallic laminations constituting the meshing working surfaces of the teeth.

6. A gear pump comprising a casing, fluid inlet and discharge ports in said casing, a driving shaft, a driving spur gear built up of stamped laminations so keyed to said driving shaft as to be non-rotatable but axially movable on said shaft, a driven spur gear meshing with said driving gear, said driven gear being built up of stamped laminations rotatively carried on a support shaft, said driven laminations being unkeyed and at least slightly self-adjustably movable relative to one another rotatively and axially free for slight movement on the support shaft, for best mesh with the driving laminations without side interference of adjacent laminations, and means to axially yieldably hold the respective laminations of the driving and driven gears closely together in face to face relation by the application of forces in the direction of the axes of the gears, the laminations all being made of stiff hard self-supporting material suitable for use as a pump gear, all being faced in the same direction relative to the direction in which they were stamped from sheet material, whereby any feathered edge produced on one lamination during the stamping operation is accommodated by the rounded edge of the next lamination, the sheared edges of said laminations constituting the meshing working surfaces of the teeth.

7. A gear pump comprising a casing, a driving shaft, a driving gear built up of laminations so keyed to said driving shaft as to be non-rotatable but axially movable on said shaft, a driven gear meshing with said driving gear, said second-named gear being built up of laminations self-adjustably rotatable and also axially movable relative to one another for best mesh with the driving gear laminations, each driven lamina-

tion meshing with and having substantially the same thickness as a specific corresponding driving lamination, pumping ports in said casing, and means to axially yieldably hold the respective laminations of the driving and driven gears together by the application of forces in the direction of the axes of the gears.

8. A gear pump comprising a casing, a driving shaft, a driving spur gear built up of laminations keyed to said driving shaft, a driven spur gear meshing with said driving gear, said driven gear being built up of laminations rotatively carried on a support shaft, said driven laminations being unkeyed and at least slightly self-adjustably movable relative to one another about the support shaft, for best mesh with the driving laminations, inlet and discharge ports in said casing, and end ports in the casing at the opposite ends of the driving and driven rotors and connected to the pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face relation by the hydraulic pressure of the fluid being pumped.

9. A gear pump comprising a casing, a driving shaft, a driving gear built up of laminations so keyed to said driving shaft in rotatively displaced or stepped relation, as to be non-rotatable but axially movable on said shaft, a driven gear meshing with said driving gear, said driven gear being built up of laminations stepped to mesh with the driving laminations, said driven laminations being axially movable relative to one another, each driven lamination having substantially the same thickness as its meshing driving lamination, pumping ports in said casing, and means to axially yieldably hold the respective laminations of the driving and driven gears closely together in face to face relation by the application of forces in the direction of the axes of the gears.

10. A gear pump comprising a casing, a driving shaft, a driving gear built up of laminations keyed to said driving shaft in rotatively displaced or stepped relation, the rotative displacement being less than the width of the tooth edge, a driven gear meshing with said driving gear, said driven gear being built up of laminations stepped to mesh with the driving laminations, inlet and discharge ports in said casing, and end ports in the casing, at the opposite ends of the driving and driven rotors and connected to the discharge pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face relation by the hydraulic pressure of the fluid being pumped.

11. A gear pump comprising a casing, fluid inlet and discharge ports in said casing, a driving shaft, a driving gear built up of laminations so keyed to said driving shaft in rotatively displaced or stepped relation as to be non-rotatable but axially movable on said shaft, the rotative displacement being less than the width of the tooth edge, a driven gear meshing with said driving gear, said driven gear being built up of laminations rotatively carried on a support shaft, each driven lamination having substantially the same thickness as its meshing driving lamination, said driven laminations being unkeyed and self-adjustably rotatable and axially movable relative to one another about the support shaft for proper mesh with the driving laminations, and means to axially yieldably hold the respective laminations of the driving and driven

gears closely together in face to face relation by the application of forces in the direction of the axes of the gears.

12. A gear pump comprising a casing, fluid inlet and discharge ports in said casing, a driving shaft, a driving gear built up of laminations so keyed to said driving shaft as to be non-rotatable but axially movable on said shaft, a driven gear meshing with said driving gear, said driven gear being built up of laminations rotatively carried on a tube or sleeve which in turn is carried on a support shaft, each driven lamination meshing with and having substantially the same thickness as a specific corresponding driving lamination, said driven laminations being unkeyed and self-adjustably rotatable and axially movable relative to one another about the sleeve for proper mesh with the driving laminations, and means to axially yieldably hold the respective laminations of the driving and driven gears closely together in face to face relation by the application of forces in the direction of the axes of the gears.

13. A gear pump comprising a casing, a driving shaft, a driving gear built up of laminations keyed to said driving shaft, a driven gear meshing with said driving gear, said driven gear being built up of laminations rotatively carried on a tube or sleeve which in turn is carried on a support shaft, said driven laminations being unkeyed and self-adjustably rotatable relative to one another about the sleeve for proper mesh with the driving laminations, inlet and discharge ports in said casing, and end ports in the casing at the opposite ends of the driving and driven rotors and connected to the pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face relation by the hydraulic pressure of the fluid being pumped.

14. A gear pump comprising a casing, a driving shaft, a driving gear built up of laminations keyed to said driving shaft in rotatively displaced or stepped relation, the rotative displacement being less than the width of the tooth edge, a driven gear meshing with said driving gear, said driven gear being built up of laminations rotatively carried on a support shaft, said driven laminations being unkeyed and at least slightly self-adjustably movable relative to one another about the support shaft, for best mesh with the driving laminations, inlet and discharge ports in said casing, and end ports in the casing at the opposite ends of the driving and driven rotors and connected to the pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face relation by the hydraulic pressure of the fluid being pumped.

15. An internal gear pump comprising a casing, a driving shaft, a driving gear built up of laminations keyed to said driving shaft, an internally toothed driven gear meshing with said driving gear, said driven gear being built up of laminations rotatively carried in the housing, said driven laminations being unkeyed and at least slightly self-adjustably movable relative to one another, for best mesh with the driving laminations, inlet and discharge ports in said casing, and end ports in the casing at the opposite ends of the driving and driven rotors and connected to the pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face

relation by the hydraulic pressure of the fluid being pumped.

16. An internal gear pump comprising a casing, a driving shaft, a driving gear built up of laminations keyed to said driving shaft in rotatively displaced or stepped relation, the rotative displacement being less than the width of the tooth edge, an internally toothed driven gear meshing with said driving gear, said driven gear being built up of laminations stepped to mesh with the driving laminations, inlet and discharge ports in said casing, and end ports in the casing at the opposite ends of the driving and driven rotors and connected to the pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face relation by the hydraulic pressure of the fluid being pumped.

17. An internal gear pump comprising a casing, a driving shaft, a driving gear built up of laminations keyed to said driving shaft in rotatively displaced or stepped relation, the rotative displacement being less than the width of the tooth edge, an internally toothed driven gear meshing with said driving gear, said driven gear being built up of laminations rotatively carried in the housing, said driven laminations being unkeyed and at least slightly self-adjustably movable relative to one another, for best mesh with the driving laminations, inlet and discharge ports in said casing, and end ports in the casing at the opposite ends of the driving and driven rotors and connected to the pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face relation by the hydraulic pressure of the fluid being pumped.

18. An internal gear pump comprising a casing, a driving shaft, a driving gear built up of relatively thin stamped laminations keyed to said driving shaft in rotatively displaced or stepped relation, the rotative displacement being less than the width of the tooth edge, an internally toothed driven gear meshing with said driving gear, said driven gear being built up of relatively thin stamped laminations rotatively carried in the housing, said driven laminations being unkeyed and at least slightly self-adjustably movable relative to one another, for best mesh with the driving laminations, inlet and discharge ports in said casing, end ports in the casing at the opposite ends of the driving and driven rotors and connected to the pressure pumping port, whereby the respective laminations of the driving and driven gears are held closely together in face to face relation by the hydraulic pressure of the fluid being pumped, and a stationary crescent disposed between the driving and driven gears at a point opposite the meshing point of the gears and between the pumping ports.

19. A gear pump comprising a casing, fluid in-

let and discharge ports in said casing, a driving shaft, a driving gear built up of laminations so keyed to said driving shaft as to be non-rotatable but axially movable on said shaft, a driven gear meshing with said driving gear, said driven gear being built up of laminations rotatively carried in said casing, the laminations of said driven gear being rotatably and axially self-adjustable relative to one another, and means to axially yieldably hold the respective laminations of the driving and driven gears closely together in face to face relation by the application of forces in the direction of the axes of the gears, said gears having a sufficient number of teeth to mesh for desired driving relation without the use of external gears, each driven lamination meshing with and having substantially the same thickness as a specific corresponding driving lamination.

20. In a gear pump comprising a casing having pressure and suction pumping ports, and a drive shaft, a gear built up of relatively thin laminations disposed face to face along the shaft, said laminations being axially movable on said shaft, and end ports at the opposite ends of said gear connected to the pressure pumping port in order to yieldably hold the laminations together by means of hydraulic forces applied in the direction of the shaft.

21. A gear pump comprising a casing, fluid inlet and discharge ports in said casing, a driving shaft, a driving gear built up of laminations so keyed to said driving shaft as to be non-rotatable but axially movable on said shaft, a driven gear meshing with said driving gear, said driven gear being built up of laminations rotatively carried on a member which in turn is rotatively carried in the casing, each driven lamination meshing with and having substantially the same thickness as a specific corresponding driving lamination, said driven laminations being unkeyed and self-adjustably rotatable and axially movable relative to one another about the member for proper mesh with the driving laminations, and means to axially yieldably hold the respective laminations of the driving and driven gears closely together in face to face relation by the application of forces in the direction of the axes of the gears.

22. In a gear pump, a driving shaft, a driving gear constituted of a plurality of laminations keyed to said shaft but being free to move axially thereon, a driven gear support shaft, and a driven gear constituted of a plurality of laminations slightly self-adjustably rotatable relative to one another for meshing with the driving laminations without side interference of adjacent laminations and also free to move axially upon said support shaft.

GUSTAVE A. UNGAR.
JOSEPH F. KELLER.