

April 16, 1946.

E. W. CLEMENTS

2,398,520

ADJUSTABLE LIQUID SEALED PUMP

Original Filed Feb. 15, 1940

2 Sheets-Sheet 1

*Fig. 1.*

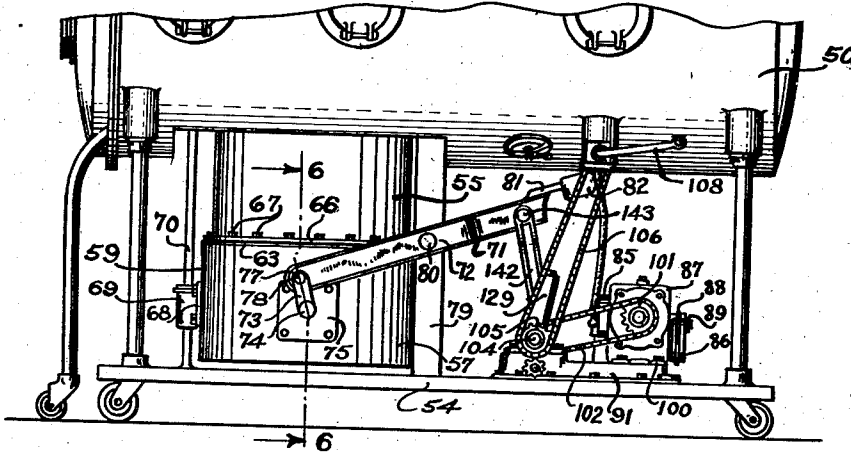


*Fig. 4.*

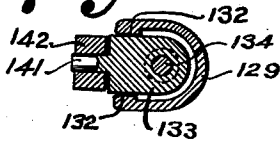


*Fig. 7.*

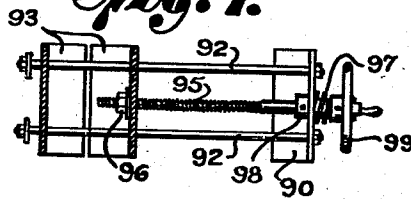
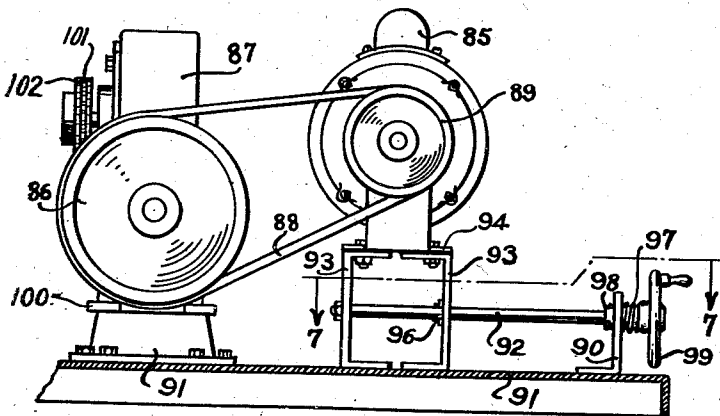


*Fig. 3.*



INVENTOR  
ERNEST W. CLEMENTS  
BY *Alfred R. Fuchs*  
ATTORNEY



## UNITED STATES PATENT OFFICE

2,398,520

## ADJUSTABLE LIQUID SEALED PUMP

Ernest W. Clements, Kansas City, Kans., assignor  
to Andrew A. Kramer, Kansas City, Mo.

Original application February 15, 1940, Serial No.  
319,091. Divided and this application July 10,  
1942, Serial No. 450,375

7 Claims. (Cl. 60—62.6)

My invention relates to pumps, and more particularly to an adjustable liquid sealed pump. This is a division of my co-pending application Serial No. 319,091, filed February 15, 1940, on Respirator, and now abandoned.

My pump is particularly adapted for use for varying the air pressure in respirators and is so constructed and arranged that the duration of the alternate pressure and vacuum, or similar pressure variations, in the respirator chamber, may be controlled, as well as the length of time that each pressure increasing and pressure decreasing operation requires.

It is accordingly a purpose of my invention to provide a driving mechanism for pumping means for varying the pressure in a chamber, that comprises telescoping means including a member fixed to the chamber and wide open at the opposite ends thereof, and a reciprocable member telescopically related to said first mentioned member, with liquid sealing means for the telescopic joint between said members, which is provided with means for adjusting the length of the stroke of the reciprocable member and the rate of reciprocation thereof.

It is a further purpose of my invention to provide a driving mechanism for pumping means of the above mentioned character that requires little power for the operation thereof, said pumping means comprising a reciprocable member which is reciprocated by means of a rocker arm, or walking beam, that is provided with means for counterbalancing the weight of the movable pumping member.

It is a further purpose of my invention to provide means for operating the walking beam or rocker arm for reciprocating said pumping member, which comprises rotatable driving means and means for varying the rate of rotation of the driving means, whereby variable speeds are possible, varying between 10 and 30 reciprocations per minute, with an infinite number of graduations between these limits.

In a respirator it is also desirable to provide means for obtaining a variation in the duration of the length of the alternate increasing and decreasing pressures in the chamber, and the stroke of the pump or of the reciprocable member thereof is accordingly adjustable to accomplish this purpose. It is accordingly a purpose of my invention to provide a pump of the above mentioned character in which the stroke of the reciprocable member can be varied to any desired extent between predetermined limits, comprising adjusting means that are self-locking so as to maintain the

stroke of the desired length after the adjustment has been accomplished, said adjusting means, preferably, comprising means for varying the throw of a crank member driven by rotatable driving means, by adjusting the position of a pivot connection between said crank and a link connecting said crank and the rocker arm.

It is a further purpose of my invention to provide a pump that can be readily driven either by power or hand, an auxiliary hand drive being provided in case of power failure, or where power is not available, the change from power to mechanical drive, and vice versa, being made by a simple adjustment, which comprises means that are capable of being adjustable by any unskilled person, such as a nurse, or other attendant at a hospital not familiar with mechanics.

It is a further purpose of my invention to provide a liquid sealed pump which may be operated with any suitable liquid that may be available, preferably, an odorless, non-volatile liquid, and which is so constructed and arranged that a minimum amount of liquid is required for sealing the pump, which will not readily be evaporated or escape from the well provided therefor in the reciprocable member. In the normal use of the pump for varying air pressures in a respirator chamber, this is of great advantage, as the pump is always ready for instant use, regardless of the length of time that it has been out of service, and there is nothing about the same that can get out of order and at the same time a gentle movement of air in and out of the respirator chamber takes place, which is more nearly like the normal human breathing action than where other types of pumping devices, such as have been previously provided, are utilized. Due to the fact that the pumping device is connected wide open to the chamber, a much greater volume of air is acted on by the pump in proportion to the capacity of the chamber, than where relatively high pressures in small quantities of air are created by means of bellows, diaphragms, or ordinary piston pumps, my pump having a very large diameter, or bore, and a very short stroke relative to the bore, to provide the desired pumping action similar to a breathing action.

Preferably, the various means comprises self locking means, simple in operation and which will not come out of adjustment unintentionally, remaining in the particular position until reset to a different position.

Other objects and advantages of my invention will appear as the description of the drawings proceeds. I desire to have it understood, however,

that I do not intend to limit myself to the particular details shown or described, except as defined in the claims.

In the drawings:

Fig. 1 is a side elevation of my improved pump applied to a respirator, which is partly broken away.

Fig. 2 is an enlarged elevational view partly broken away, of the driving means for the pumping means.

Fig. 3 is an elevational view of a portion of the driving mechanism as viewed from the right hand end of Fig. 2.

Fig. 4 is a section taken on the line 4—4 of Fig. 5 on a slightly enlarged scale.

Fig. 5 is a sectional view through a portion of the driving mechanism taken substantially on the line 5—5 of Fig. 2.

Fig. 6 is a sectional view taken on the line 6—6 of Fig. 1.

Fig. 7 is a section taken on the line 7—7 of Fig. 3, and

Fig. 8 is an enlarged fragmentary sectional view showing the sealing means and connection between the walking beam and reciprocable member corresponding to the left side of Fig. 6.

Referring in detail to the drawings, my improved pump is shown as being provided on a respirator that has a body portion 50, which is mounted on suitable legs or posts extending from a base 54, said respirator being provided with suitable casters or rollers on the legs thereof and on the base, as will be evident from the drawings, but the particular mounting of the respirator is of no importance as far as the pump structure is concerned, except that the variations in pressure in the respirator are controlled by means of the liquid sealed pumping means, and that the tubular member 55 forming the stationary tubular member of the pump, depends from the body portion 50 and is rigidly secured thereto in liquid tight relation, communicating with the body portion through a wide unrestricted opening 56 of substantially the cross sectional area of the tubular member 55, which is shown as being an open ended cylinder. Cooperating with said tubular member 55 is a reciprocable pumping member 57, which is, preferably, provided with an inner cylindrical wall 58 and an outer cylindrical wall 59, a transverse wall 60 being provided, closing the end thereof within the top edge of the cylindrical wall 58, and a bottom transverse wall 61 of a ring-like character being provided, connecting the bottom edges of the cylindrical walls 58 and 59. A piston is thus provided that has an end wall 60 and an annular channel, or well, therein extending around the same that receives the bottom edge of the tubular member 55, and which is filled with a liquid 62 to such an extent that the bottom edge of the member 55 will always be under the level of the liquid, so that said liquid forms a seal between the wall 55 and the piston, or reciprocable member 57.

A flexible gasket member 63 is also, preferably, provided, that engages the member 55 and is clamped on an inwardly directed flange 64 on the member 57, which has a depending lip 65, the clamping being accomplished by means of a clamping ring 66, and suitable securing elements 67 extending through the flange 64 and said ring 66.

Suitable mechanism is provided for reciprocating the member 57 and means is also, preferably, provided for preventing rotational movements of the member 57 relative to the member 55 com-

prising a bracket 68 fixed on the member 57 and having an enlargement 69 thereon that is slidably mounted on a guide rod 70 that is suitably fixed to the body portion 50 and to the base member 54.

The means for reciprocating the member 57 comprises a rocker arm, or walking beam member 71, which is bifurcated to provide a pair of arms 72, which are pivotally mounted on standards 79 extending between the body portion 20 and the base 54. The bifurcations, or arms 72 of said member 71 are provided with links 73 that connect the same with headed pivot members 74, provided on brackets 75 fixed on the member 57. Said links are provided with bearing portions 76 rotatable on the headed members 74 and with suitable bearing portions 77, that receive the headed pivot members 78 that pivotally connect said links with the arms 72 of the rocker arm, or walking beam 71.

It will be obvious that the reciprocable member 57 will be moved up and down as the member 71 is oscillated about its pivots 80 fixed on the standards 79. Means is provided for counterbalancing the weight of the member 57 about said pivots 80, so that a minimum amount of power will be required for reciprocating said member 57, said counterbalancing means comprising a rod-like extension 81 on the member 71, on which a counterweight 82 is adjustably mounted, said counterweight being shown as being held in adjusted position by means of suitable set screws 83, (see Fig. 2), said rod-like member being provided with a stop flange 84 thereon to prevent accidental disengagement of the weight 82 from the member 81, a washer being shown as providing said flange, the same being held in position by means of a nut 52 engaging a reduced end portion of the member 81.

The stroke of the member 57 is varied by varying the amplitude of the oscillation of the member 71, as will be described below. The number of reciprocations of the member 57 per minute is controlled by a variable speed drive mechanism, which will be described below.

A motor 85 drives a pulley 86 through a suitable variable speed pulley device which may be of any well known standard type. Said pulley 86 is provided with a V-groove for receiving the V-belt 88. Said V-belt 88 operates over the variable speed pulley device, comprising a pair of pulley members 89 that are beveled on their inner faces to receive the belt 88 between them, and which are provided with suitable resilient means tending to move the members 89 toward each other, the pulley operating in a manner such that the effective diameter thereof is dependent upon the depth to which the V-belt 88 enters between the members 89, and this is again dependent upon the tension put on the belt 88, which acts on the resilient means to force the members 89 apart in a well known manner. Means is provided for adjusting the variable speed mechanism thus provided by means of the variable speed pulley device 89, which broadly comprises means for varying the spacing between the pulley 86 and the members 89.

Said means comprises a suitable bracket, such as the angle member 90 fixed on the base 91 through which a pair of guide rods 92 extend, which also extend through suitable openings in a pair of channel members 93 secured together by a top plate 94 and forming a mounting for the variable speed pulley device comprising the members 89. Said mounting is thus longitudinally adjustable on the rods 92 and on the base

91, which is fixed on the base 54, and the particular adjusted position thereof is determined by means of a screw-threaded rod-like member 95, (see Fig. 7), which is screw-threadedly received within an internally screw-threaded nut 96, that is fixed to one of the members 93, by welding or otherwise, said rod-like member 95 being held against longitudinal movement through the member 90 by means of a collar 98 on the rod 95 and the shoulder formed by an extension on the enlarged hub on the hand wheel 99, engaging opposite sides of the member 90. A spring 97 is held under compression between a shoulder on said hub on the hand wheel 99 and said member 90 to create sufficient friction to hold the hand wheel in adjusted position, the threaded connection between the member 96 and rod 95 acting as self-locking adjusting means, together with said frictional means, for the variable speed pulley device.

The shaft of the pulley 86 being fixed relative to the base 91, as will be obvious, the movement of the variable speed pulley device 89 on the base 91 will adjust the spacing of the members 86 and 89, and thus vary the speed of the shaft carrying the pulley 86. The motor 85, which carries the variable speed pulley device 89 on the shaft is, of course, also mounted on the movable base made up of the members 93 and 94. The shaft that carries the pulley 86 is the input shaft of a speed reduction device 87 of a standard type, which has a base member 100, that is mounted on the member 91 in fixed position. It will accordingly be obvious that the position to which the movable base, made up of the members 93 and 94, is adjusted by means of the hand wheel 99 will determine the speed at which the sprocket 101 on the output end of the speed reducer 87 will rotate.

A chain 102, (see Fig. 2), that operates over the sprocket 101, also operates over a sprocket 103, (see Fig. 5), which is loosely mounted on the shaft 104 so that said sprocket 103 can rotate on the shaft 104 when desired. Means is provided for coupling the sprocket 103 to the shaft 104, which will be described below. A sprocket 105, (see Figs. 2 and 5), is mounted in a similar manner to that of the sprocket 103 on the shaft 104, and this sprocket has a sprocket chain 106 operating over the same, which operates over a sprocket 107 rotating with the crank 108, the sprocket 105 being held on said shaft by the collar 53.

Means is provided for connecting either the sprocket 103 or the sprocket 105 with the shaft 104, so as to reciprocate the pumping mechanism provided, this being dependent upon whether it is desired to operate the device by manual means or by means of the motor 85, or because of the necessity of operating the respirator by means of the hand crank in case of power failure. Said means comprises a shiftable clutch member 109, which is keyed on the shaft 104, so as to rotate therewith, but is slidable lengthwise of said shaft. Said shiftable clutch member is provided with alternating projections and recesses that cooperate with similar projections and recesses on either the member 105 or the member 103, depending upon the position of the shiftable clutch member 109, to rotate the member 109 either as a unit with the member 103 or as a unit with the member 105. Said recesses are indicated by the numeral 110 and the projections by the numeral 111 in Fig. 5.

The shifting mechanism for the clutch mem-

ber 109 comprises a pair of arcuate shoes 112 that operate in the groove 113 on the member 109, said shoes 112 being mounted on the arms 114 of a shifting member, so that these can adjust themselves to the position of said shifting member about its pivot 116 without binding in the groove in the clutch member 109.

A spool-like member 120 having a pair of flanges 121, that are located one on each side of the shifting member is internally threaded to receive the screw-threads on the threaded rod-like member 122. Said spool-like member 120 has a forward extension 123, which has a handle 124 thereon, which is provided for rotating the spool-like member to adjust the same on the screw-threaded rod-like member 122, the internal threads in said spool and extension being indicated by the numeral 125. The threaded-rod-like member 122 has a head 126 thereon that is fixed to the wall 127 of the base of the bearing member 128 mounted on the base 91, so that it will not rotate.

Thus rotation of the member 124 will move the spool-like member 120 toward and away from the wall 127 and thus lock the shifting member 119 on its pivot 116 to adjust the clutch member 109 to a position such that it will either be in engagement with the motor driven sprocket 103 or the manually driven sprocket 105 to rotate the shaft 104.

The shaft 104 is mounted on the bearing member 128 and has fixed thereon to rotate therewith a tubular crank member 129, said crank member being provided with reinforcing means 130 at its point of securement to the shaft 104. Said member 129 has a pair of flat faces 132 thereon, that lie opposite each other and act as guides for a nut-like block 133, which will be described more in detail below. A shaft 134 is mounted rotatably in the end walls 135 and 136 of the tubular member 129, and a collar 137 and a crank 138, fixed to the opposite ends thereof, hold said shaft 134 in assembled position in the tubular crank member 129 against endwise movement as the same is rotated.

Said shaft 134 is provided with a thread 139 thereon that engages an internal thread 140 in the nut 133, and as the flat faces on the nut 133 engaging the flat faces 132 on the member 129 (see Fig. 4) prevent any rotation of said member 133, it will be obvious that rotation of the crank 138 will adjust the screw-threaded nut, or block, 133 lengthwise on the shaft 134 to any desired position thereof. A pivot member 141 projects from the nut, or block, 133 and has one end of the crank 142 pivotally mounted thereon. The axis of the pivot 141 is so located relative to the end of the block 133 nearest the wall 136 that when said block 133 is in its one extreme adjusted position, with one end wall thereof in engagement with the wall 136, the axis of said member 141 will be in alignment with the axis of the shaft 104, and accordingly the arm 142 will have the end thereof receiving the pivot 141 lying on the center line of the shaft 104.

Upon reference to Figs. 2 and 5 it will be obvious that when such is the case the arm, or link, 142 will cause no oscillation of the rocker arm or walking beam 71, as the position of the pivot 143 and that of the pivot 141 will not change as the shaft 104 rotates. It will further be obvious that the further the block, or nut, 133 is moved from this position by rotation of the crank 138 the greater the distance between the center line of the shaft 104 and the axis of the shaft 141,

resulting in a rotation of the lower end of the link 142 pivoted on the pivot member 141 in a circle of a radius dependent upon the position of said nut, or block, 133 and thus the amplitude of the oscillation of the rocker arm or walking beam 71, will be increased the further the nut, or block, 133 is from the end 136 of the tubular crank member 129. It will also be obvious that due to the long thread in the nut 133 in engagement with the threads 139 of the shaft 134, an accurate location of the pivot 141 can be established, and furthermore that self-locking adjusting means for this pivot is thus provided. Obviously the stroke of the member 57 is determined by the amplitude of the reciprocation of the member 71, as above mentioned.

The purpose of the device being to provide a pump for creating pressure changes in a respirator chamber, such as the chamber 50, it is necessary in order to match as closely as possible the breathing action of a human being, to provide a series of duplicate pressure changes in the chamber 50 that have not only the frequency of the increases and decreases in pressure there of equal to the number of respirations per minute of the patient, but that each of these duplicate pressure changes be such as to produce as nearly as possible the peculiarities of the breathing action of the patient in the chamber. In order to accomplish this, it is necessary that the pressure in the chamber surrounding the chest of the patient changes in such a way as to cause an inspiration as nearly similar to that of the particular patient in the chamber as can be produced, and an expiration by change in the pressure of the chest wall that is also substantially the same as would be naturally produced by that particular patient. The actual inspiration and actual expiration are of different lengths with different patients, depending upon the peculiarities of that patient, and are not in any manner directly related to the rate of respiration. However, each normal inspiration of a given patient is the same each time that it takes place, that is, each inspiration is the same as every other inspiration, and each expiration is the same as every other expiration. Also the number of respirations per minute is the same under normal conditions for that particular patient over long periods of time. The character of the pressure changes found by experiment and study to be necessary to get the closest approximation to the characteristic manner in which a human being breathes in and breathes out air, are those that would be produced in a closed rigid walled chamber if a rigid end wall of that chamber were moved part of the way toward the opposite end wall and back again in the manner of a piston driven by a crank, this producing pressure changes that at first take place slowly, then more rapidly as the middle of the stroke is reached, and then gradually more slowly until the opposite end of the stroke is reached, due to the fact, of course, that the crank is rotating and the connection of the piston with the crank moves in a circular path, while the crank moves in a straight line.

Due to the provision of the open ended cylindrical member 55 in wide open communication with the chamber 50, the reciprocating movements of the piston having the transverse wall 60 will produce the same character of pressure changes in the chamber 50 as if an end wall of the chamber 50 were moved back and forth in the manner above stated, as the cylindrical

member 55 is a continuation or adjunct of the member 50. The movement of the piston member or pumping member 57 is accomplished normally by means of the motor 85 by a positive driving connection, which positively moves the member 57 in response to the rotation of the crank member 129, so as to produce the same characteristics in the movement of the member 57 in both directions, as would be true if the crank 129 were directly connected with the reciprocable member 57. The drive is from the motor 85 through the variable speed pulley device 89 and the speed reduction device 87 to drive the sprocket 101, which in turn drives the chain 102 to rotate the sprocket 103 on the shaft 104 carrying said crank 129. The crank 129 oscillates the walking beam 71 through the link 142, which reciprocates the piston member 57 through the link connection 73. The amplitude of the movement of the walking beam and thus the stroke of the piston 57 is adjusted by adjusting the position of the pivot 141 by means of the crank 138 and the rate of reciprocation of the member 57 is adjusted by means of the adjustment of the variable speed pulley device 89 by means of the hand wheel 99 so as to move the pair of pulleys 89 toward or away from the pulley 86 to thus cause the belt to ride either closer to the periphery or nearer to the center of rotation of said variable speed device 89.

When a patient is placed in the chamber 50 the speed of the device is adjusted to obtain as nearly as can be estimated the frequency of reciprocation of the member 57 to that at which the patient is assumed to breathe normally, and the stroke of the member 57 is adjusted by means of the crank 138 to a length that, from the characteristics of the patient, appears to be about the right stroke for that patient. This, of course, depends upon the chest capacity of the patient, as well as the normal chest expansion and other peculiarities of the breathing of the patient. A physician can readily determine from the actions of the patient in the respirator, even if not entirely conscious, whether the pressure changes in the chamber 50 are normal in frequency and in other characteristics to those of the patient, as the patient will attempt to fight the action of the machine if it is not proper, or will otherwise show discomfort or annoyance. By adjustment of the member 138 and the member 99 the exact frequency and length of stroke that will be satisfactory for the particular patient can be established. As the adjusting means operated by the members 99 and 138 are self locking and will remain in adjusted position, the stroke length and stroke frequency will be maintained the same, as long as that patient is in the chamber 50, this usually being for great lengths of time if the patient survives the first few hours or first few days in the respirator while desperately ill.

As the device is used over such great periods of time ordinarily, it is quite possible that an emergency will arise when there is no power temporarily available to operate the motor 85, and if such an emergency develops the movable clutch member 109 is shifted from the position shown in Fig. 5, which is its normal position, so that the same engages the sprocket 105, and the crank 108 is rotated manually the same number of revolutions per minute that the shaft 104 has been driven through the drive from the motor 89, the stroke of the piston remaining the same, as the adjustment of the pivot member 141 on the member 129 does not have to be disturbed

at all to make the change in motive power from power drive to manual drive. All of the adjusting means are so constructed that any person without any mechanical ability can operate the same to adjust the length of stroke, the frequency thereof, or to shift from manual to power drive, or vice versa, by turning a handle or other operating member, thus enabling a physician or nurse by mere observation of the patient to bring the device in proper adjustment without the necessity of any mechanical ability, and enabling a nurse or other person not skilled in mechanics to shift to manual operation of the device when an emergency develops, without any instruction except to rotate the clutch operating member 124 to shift to the crank drive and to then rotate the crank the proper number of times per minute, the sprockets 107 and 105 being made the same size so that this can be simply and easily accomplished.

A device is thus provided that not only provides for an alternate increase and decrease in pressure in a chamber, but one that has certain characteristics which can be changed by adjusting the length of the stroke, but all of which are of the same general character, that of a piston moving in a closed chamber or cylinder through a stroke only part of the length of the chamber or cylinder. The actual pressure changes are very small and the liquid seal provided does not change very materially in level either on the inside or outside of the cylindrical wall 55 during the strokes of the member 57.

What I claim is:

1. A device of the character described having a large bore and relatively short stroke, comprising a rigid tubular member wide open at its opposed ends, a reciprocable member telescopically related to said tubular member having spaced inner and outer rigid tubular wall portions connected by a transverse wall extending between the same at the bottom thereof to provide an annular well receiving said tubular member and having an imperforate flat transverse end wall extending across the upper end of said inner tubular wall to close said end thereof, a sealing liquid in said well, and means for reciprocating said reciprocable member, comprising a lever having a forked portion embracing said reciprocable member and mounted to pivot about an axis between the ends thereof, driving means connected with said lever for pivotally rocking the same about said axis in both directions, and rigid links pivotally connected with said reciprocable member and the forks of said lever adjacent one end thereof.

2. A device of the character described having a large bore and relatively short stroke, comprising a rigid tubular member wide open at its opposed ends, a reciprocable member telescopically related to said tubular member having spaced inner and outer rigid tubular wall portions connected by a transverse wall extending between the same at the bottom thereof to provide an annular well receiving said tubular member and having an imperforate flat transverse end wall extending across the upper end of said inner tubular wall to close said end thereof, a sealing liquid in said well, means for reciprocating said reciprocable member, comprising a lever mounted to pivot about an axis between the ends thereof, driving means connected with said lever for pivotally rocking the same about said axis in both directions, and short rigid links pivotally connected with said reciprocable member and the

forks of said lever adjacent one end thereof, and guiding means externally and eccentrically of said reciprocable member for holding said reciprocable member from rotation about its axis.

3. A device of the character described having a large bore and relatively short stroke, comprising a rigid tubular member wide open at its opposed ends, a reciprocable member telescopically related to said tubular member having spaced inner and outer rigid tubular wall portions connected by a transverse wall extending between the same at the bottom thereof to provide an annular well receiving said tubular member and having an imperforate flat transverse end wall extending across the upper end of said inner tubular wall to close said end thereof, a sealing liquid in said well, flexible sealing means for said well on said outer wall wipingly engaging said tubular member, and driving means for positively reciprocating said reciprocable member in both directions.

4. A device of the character described having a large bore and relatively short stroke, comprising a rigid tubular member wide open at its opposed ends, a reciprocable member telescopically related to said tubular member having spaced inner and outer rigid tubular wall portions connected by a transverse wall extending between the same at the bottom thereof to provide an annular well receiving said tubular member and having an imperforate transverse end wall extending across the upper end of said inner tubular wall to close said end thereof, a sealing liquid in said well, means for reciprocating said reciprocable member, comprising a lever having a bifurcated portion providing a pair of arms embracing said reciprocable member, said lever being mounted to pivot about an axis closely adjacent said reciprocable member, short rigid links pivotally connected with said arms adjacent the ends thereof and pivotally connected with said reciprocable member, and driving means connected with said lever on the opposite side of said pivotal axis from said reciprocable member to positively rock said lever about said axis in both directions.

5. A device of the character described having a large bore and relatively short stroke, comprising a rigid tubular member wide open at its opposed ends, a reciprocable member telescopically related to said tubular member having spaced inner and outer rigid tubular wall portions connected by a transverse wall extending between the same at the bottom thereof to provide an annular well receiving said tubular member and having an imperforate transverse end wall extending across the upper end of said inner tubular wall to close said end thereof, a sealing liquid in said well, means for reciprocating said reciprocable member, comprising a lever having a bifurcated portion providing a pair of arms embracing said reciprocable member, said lever being mounted to pivot about an axis closely adjacent said reciprocable member, headed trunnions fixed on said reciprocable member between the ends thereof, short rigid links pivotally connected with said trunnions and with said arms adjacent the ends thereof, and driving means connected with said lever on the opposite side of said pivotal axis from said reciprocable member to positively rock said lever about said axis in both directions.

6. A device of the character described having a large bore and relatively short stroke, comprising a rigid tubular member wide open at its opposed ends, a reciprocable member telescopically related to said tubular member having spaced inner and outer rigid tubular wall portions con-

nected by a transverse wall extending between the same at the bottom thereof to provide an annular well receiving said tubular member and having an imperforate transverse end wall extending across the upper end of said inner tubular wall to close said end thereof, a sealing liquid in said well, means for reciprocating said reciprocable member, comprising a lever having a bifurcated portion providing a pair of arms embracing said reciprocable member, said lever being mounted to pivot about an axis closely adjacent said reciprocable member, headed trunnions fixed on said reciprocable member between the ends thereof, short rigid links pivotally connected with said trunnions and with said arms adjacent the ends thereof, a guide rod extending parallel to the axis of said reciprocable member externally thereof, a laterally extending bracket on said reciprocable member slidably engaged with said guide rod, and driving means connected with said lever on the opposite side of said pivotal axis from said reciprocable member to positively rock said lever about said axis in both directions.

7. A device of the character described having a large bore and relatively short stroke, comprising a rigid tubular member wide open at its opposed ends, a reciprocable member telescopically related to said tubular member having spaced inner and outer rigid tubular wall portions connected by a transverse wall extending between the same at the bottom thereof to provide an annular well receiving said tubular member and having an imperforate flat transverse end wall extending across the upper end of said inner tubular wall to close said end thereof, a sealing liquid in said well, and means for positively reciprocating said reciprocable member in both directions, comprising a walking beam mounted to pivot about an axis between the ends thereof, short rigid links connecting said reciprocable member with the said walking beam adjacent one end thereof, a reduced extension on said walking beam, at the other end thereof, a counterweight adjustably mounted on said reduced extension, and means for rocking said walking beam.

ERNEST W. CLEMENTS.