Oct. 6, 1953 R. T. SHEEN ET AL 2,654,326

CONSTANT DELIVERY PUMP

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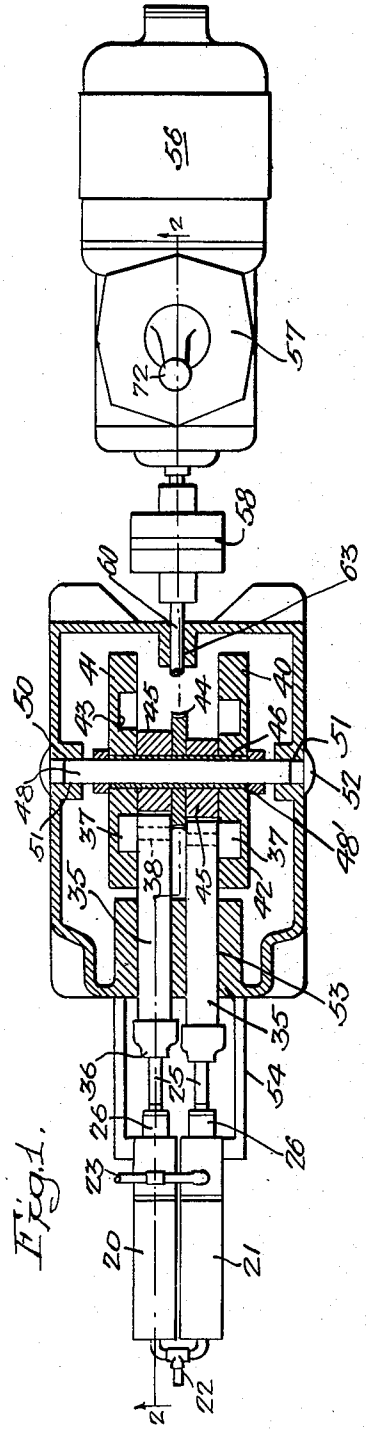


Fig. 1.

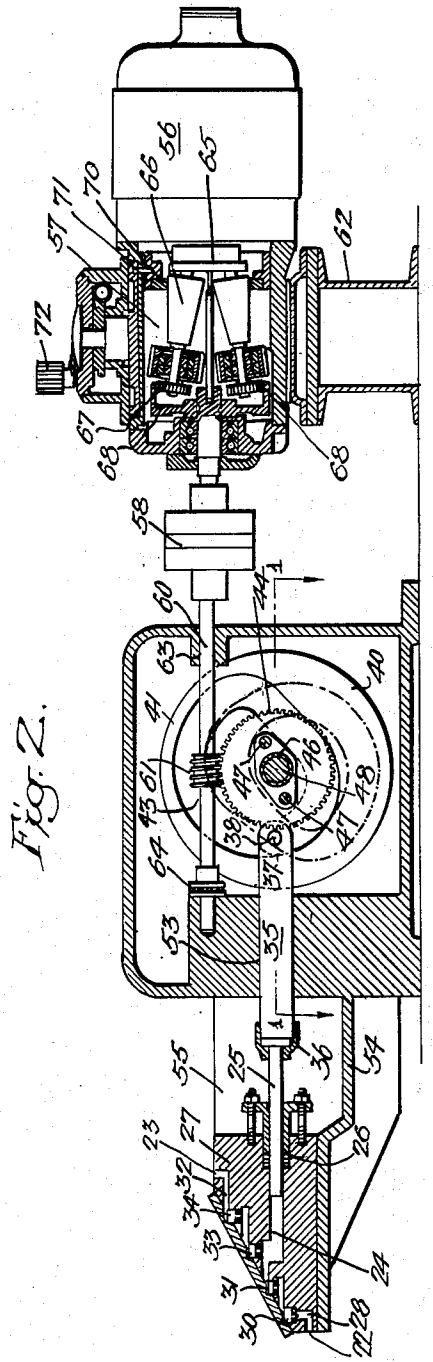


Fig. 2.

INVENTORS
Robert T. Sheen,
Royal Bartlett Saalfrank
John W. Welker.
by Dunwoody, Clarke, Colman & Dorn
Attorneys.

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Fig. 3.

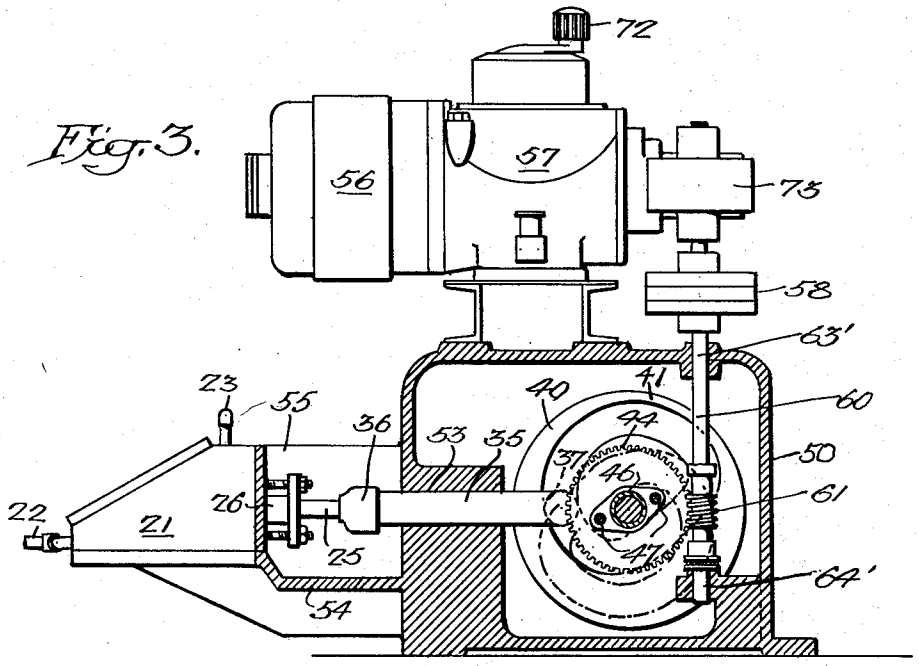
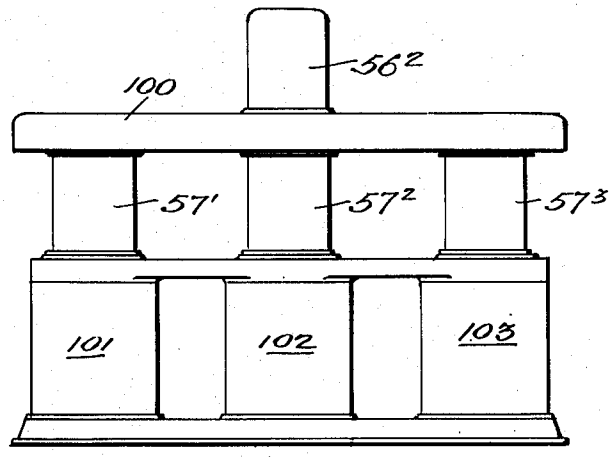


Fig. 7



INVENTORS
Robert T. Sheen
Royal Bartlett Saalfrank
John W. Welker.
by Dawson and Sons
Attorneys.

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CONSTANT DELIVERY PUMP

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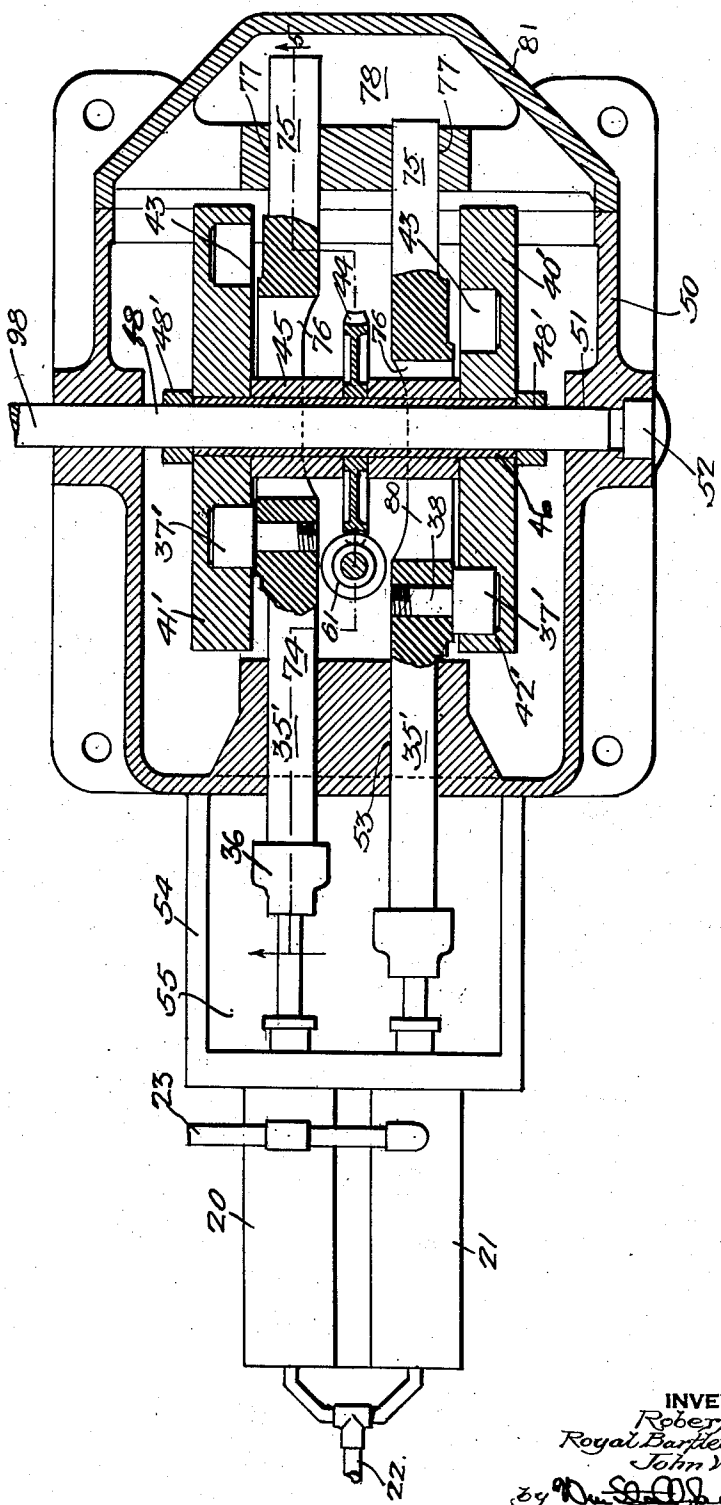


Fig. 4.

INVENTOR
Robert T. Sheen
Royal Bartlett Saalfrank
John W. Welker.
By Dunlap, Laseman and Sam
Attorneys.

Oct. 6, 1953 R. T. SHEEN ET AL 2,654,326

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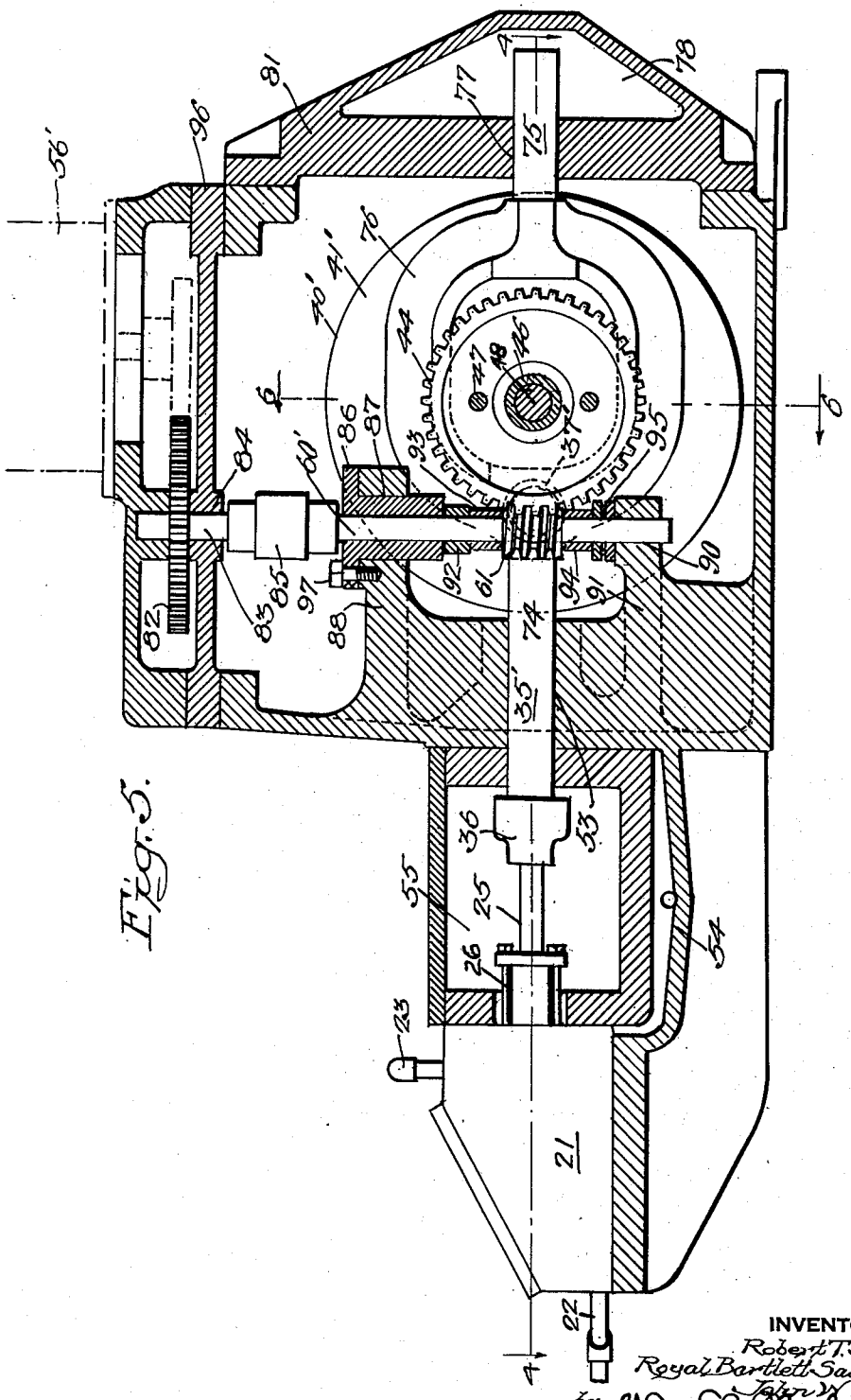


Fig. 5.

INVENTORS.
Robert T. Sheen
Royal Bartlett Saalfrank
John W. Welker
by
Attorneys.

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Fig. 8

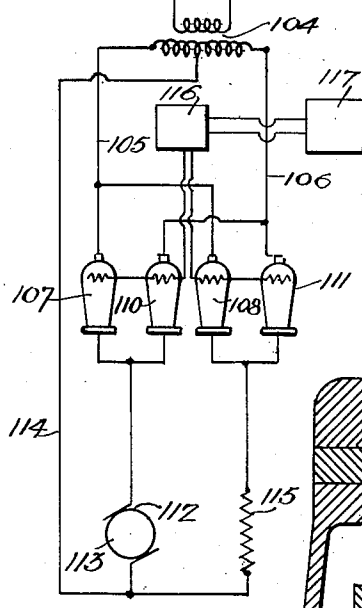


Fig. 6.

INVENTORS
Robert T. Sheen
Royal Bartlett Saalfrank
John W. Welker
by Wallace Cushman Snow & Snow
Attorneys

Patented Oct. 6, 1953

2,654,326

UNITED STATES PATENT OFFICE

2,654,326

CONSTANT DELIVERY PUMP

Robert T. Sheen, Wyndmoor, Pa., Royal Bartlett Saalfrank, Gulfport, Fla., and John W. Welker, Jenkintown, Pa., assignors to Milton Roy Company, Chestnut Hills, Pa., a corporation of Pennsylvania

Application October 7, 1948, Serial No. 53,232

2 Claims. (Cl. 103—170)

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The present invention relates to constant delivery pumps of the character which will produce a uniform or constant output throughout the pumping cycle.

A purpose of the invention is to simplify the design, construction and maintenance of constant delivery pumps particularly with respect to the cams which are employed.

A further purpose is to accomplish change in the pump delivery by change in speed without change in the constant level of the delivery throughout the pumping cycle.

A further purpose is to design the constant delivery pumps so that cam calculations can more readily be made for differences in pressures, viscosities, speeds and volumes.

A further purpose is to permit the control of the output of a constant delivery pump by speed change, while providing corrections for one pump with respect to another in the constant delivery pump assembly, so that the delivery at one level will be constant throughout the cycle.

A further purpose is to reduce the number of parts and particularly to reduce the number of connections and the amount of lost motion possible in the operating mechanism of a constant delivery pump, while at the same time obtaining less frictional loss and greater efficiency, particularly avoiding the production of vector components of motion which are not directly useful in the pump operation.

A further purpose is to arrange the operating mechanism to and including the cams in straight line relation along a plane which includes the centers of the lines of motion of the pumping elements so as to obtain maximum effectiveness particularly at high pressures and at high speeds of operation.

A further purpose is to mount the cams on a cam unit which extends through the interiors of yokes which interconnect with the pumping elements, the yokes desirably being supported and guided at both ends of the bifurcated portions.

A further purpose is to drive the cam unit through a worm wheel forming part of the cam unit and desirably to operate the worm wheel from a worm unit consisting of a worm, shaft and bushings capable of being removed as a unit.

A further purpose is to provide great accuracy of support of the cam unit by turning it on a shaft supported at opposite ends of the cam unit comparatively remote from the center, and preferably to use a stationary shaft on which the cam unit turns with bearing support being provided by a bushing.

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Further purposes appear in the specification and in the claims.

In the drawings we have chosen to illustrate a few only of the numerous embodiments in which our invention may appear, choosing the forms shown from the standpoints of convenience in illustration, satisfactory operation and clear demonstration of the principles involved.

Figures 1 and 2 illustrate one embodiment of the invention.

Figure 1 is a sectional plan view of a constant delivery pump in accordance with the invention, the section being taken on the line 1—1 of Figure 2.

Figure 2 is a sectional side elevation of Figure 1, the section being taken on the line 2—2 of Figure 1.

Figure 3 is a view corresponding to Figure 2 illustrating a variation.

The preferred embodiment of the invention is illustrated in Figures 4 to 6 inclusive.

Figure 4 is a sectional plan view of this embodiment, the section being taken on the line 4—4 of Figure 5.

Figure 5 is a vertical section of Figure 4 on the line 5—5.

Figure 6 is a vertical section of Figure 5 on the line 6—6.

Figure 7 is a front elevation of a further embodiment of the invention.

Figure 8 is a diagrammatic circuit diagram of a speed changer which may be employed in the invention.

In the drawings like numerals refer to like parts throughout.

Describing in illustration but not in limitation, and referring to the drawings:

Efforts have been made in the past to obtain constant delivery by a pump throughout its pumping cycle, as exemplified in Baker U. S. Patent 1,382,450, granted June 21, 1921. These prior devices have been complicated and expensive, including many parts, with numerous points of connection, great opportunity for lost motion, and great complexity particularly in calculation of the cams, since the forces are not applied directly or in straight line relation, and vectors are introduced. These prior art designs have not been capable of sufficient structural support of the moving parts to permit safe operation at high pressures and have not been susceptible of sufficient balance to permit operation at high speeds. Frictional losses in the prior art forms have been high and efficiencies have accordingly been low.

The present invention is designed to overcome these difficulties and to produce a much simplified and less expensive form, which will have fewer moving parts and particularly fewer cams, fewer points of interconnection and therefore less danger of inaccuracy from lost motion, less frictional loss and greater efficiency. In the present invention a straight line relationship is maintained at the point of cam force application, so that no motion component is introduced which is only partially applicable (through a resultant) to the motion of the pumping elements.

In accordance with the invention the great simplicity of the design and the support provided for all elements permits operation at high pressures. Likewise the extent of support and the possibility of dynamically balancing permits operation at high speeds.

Cam correction is greatly simplified by the present invention. Not only are there fewer corrections since no corrections are necessary for change in angularity of positions of the operating parts, but also those corrections made are simplified.

It will be evident that each of the pumps (two or more) which makes up the constant delivery pump has a cam which is respectively out of phase with the cam of another pump. Thus if there are two pumps the cams will be approximately 180° out of phase. If there are three pumps, the cams will be approximately 120° out of phase. In the preferred practice however this figure is not exact, since there is preferably an overlap at the beginnings of the pumping strokes of individual pumps, so that with two pumps the pumping stroke of each pump will preferably be somewhat greater than 180°.

The detail of the cam corrections forms no part of the present invention and has been set forth very fully in Saalfrank U. S. application Serial No. 27,294, filed May 15, 1948, now Patent No. 2,620,734, for Constant Delivery Pump, incorporated herein by reference. Suffice it to say that the cams are corrected so that the total delivery of all pumps is the same at all points in the pumping cycle, and this remains true notwithstanding change in the volume of delivery. Corrections are made in the preferred embodiment for pressure, viscosity, speed and volume, but the pump delivery will remain constant over a wide variation in capacity once the corrections are applied.

Due to the straight line character of the cam action and the elimination of extra parts, the application of cam corrections for the various factors is greatly simplified, since vectors do not require consideration.

In accordance with the present invention the change in volume of delivery of the pump is accomplished by change in speed without in any way impairing the uniformity of delivery at a particular level.

The accuracy of the device is greatly improved by mounting the cams together in a cam unit which turns inside the interiors of yokes, and which is supported at relatively widely spaced points by a cam shaft. The cam shaft is preferably stationary and the cam unit preferably is provided with a bushing on the shaft. Likewise in the preferred embodiment the worm which drives the cam unit is assembled with its components as a separate unit before insertion into the mechanism, thus greatly facilitating assembly.

As shown in the form of Figures 1 and 2, the constant delivery pump comprises pumps **20** and **21** having a common inlet **22** and a common outlet **23**. Each pump has a cylinder **24** and a pumping element **25**. The pumping element may suitably be a piston passing through a stuffing box **26**. It will be understood of course that the pumping element **25** may be of any suitable type, and the detail of this element is not important to the present invention, the question of whether it be a piston, diaphragm or bellows not being critical.

The pump may be of any of a wide variety of types, but will preferably conform to Milton Roy Sheen U. S. Patent 2,263,429, granted November 18, 1941, for Pump, or U. S. Patent 2,367,893, granted January 23, 1945, for Liquid Pump. The cylinder block **27** has inlet valve passages **28** which contain inlet valves **30** and **31**, preferably of the ball type, and the outlet passages **32** have additional valves **33** and **34** which are also preferably of the ball type. The respective inlet valves are in series and the respective outlet valves are in series. The pumping elements **25** include extensions **35** in the form of plungers which are effectively part of the pumping elements and are united thereto by tubular nuts **36** suitably threaded to the extensions and surrounding enlarged ends of the pistons. The extensions **35** may be comparatively short as shown in the form of Figures 1 and 2 and of Figure 3, or may be elongated and yoke-shaped as shown in Figures 4 to 6 inclusive.

All of the pumping elements are aligned side by side and the center lines of motion of the pumping elements include the center lines of motion of the extensions **35**. Thus it will be seen that these center lines of motion lie in the same plane whether there be two pumps or more than two lined up side by side. In this plane is located the center of a follower **37**, suitably a roller, pivoted on a pin **38**.

A cam unit **40** operates the followers. In the form of Figures 1 and 2 the cam unit comprises cams **41** and **42** having face cam tracks **43**. The cam tracks conveniently face towards one another in the case where two pumps are employed, and the followers occupy positions in the cam tracks.

Located intermediately between the cams, coaxial therewith and connected thereto is a worm wheel **44**. Spacers **45** suitably occupy positions between each cam and the worm wheel to properly position the cams.

A sleeve or bushing **46** passes through the interior of the cams, spacers and worm wheel, and provides internal bearing for them. The cam unit is united together by bolts **47** extending through the cams, spacers and worm wheel.

The cams are arranged approximately 180° out of phase, as shown in Figure 2, and each includes correction for the other as set forth in detail in Saalfrank application above referred to. Thus with the correction provided there will normally be a slight overlap of the pumping strokes, (one pump beginning the pumping stroke before the other finishes), but the volume delivered by the pumps in the aggregate will be the same, whether a single pump is providing the output or a plurality of pumps are at the moment contributing to the output.

The cam unit is rotatably supported on a shaft **48** whose center is in the plane above referred to which includes the lines of motion of the centers of the various pumping elements. The shaft is transverse to such lines of motion. Collars **48'** center the cam unit on the shaft. The shaft is preferably stationary, and is supported in a housing **50** at two widely spaced supports **51**, so that

great accuracy in positioning of the shaft can be obtained without requirement of high precision in the location of the supports 51. Caps may be provided at 52 to seal the housing.

The same housing 50 likewise provides sliding bearing support 53 for the pumping elements or their extensions so as to guide them during reciprocation.

An extension 54 from the housing may desirably support the pump proper. The space around the packing gland may suitably be enclosed by a well 55, which may be used if desired to retain a sealing liquid.

The drive is accomplished by an electric motor 56 driving to a speed changer 57 connected to a coupling 58 which drives a shaft 60 carrying a worm 61. The motor and speed changer is supported on a base 62. The shaft 60 has bearing support at one end in the housing at 63 and has journal and thrust bearing support at the other end in the housing 64.

The speed changer shown in this form is of the well known mechanical variable speed intermeshing type in which the motor drives a roller carrier 65 having revolvably mounted thereon cone rollers 66 carrying pinions 67 which intermesh with a ring gear 68 on the output side. The speed of rotation of the rollers and therefore of the pinions as they revolve is controlled by a frictionally engaging stationary control ring 70 which is moved longitudinally of the cone rollers by an adjustment cam 71 operated by a control handle 72. One commercial type of cone speed changer of the character herein described is the Graham.

The form of Figures 1 and 2 employs a motor and drive located to one side of the constant delivery pumping housing. Figure 3 shows a modification in which the device is mounted on the constant delivery pump housing, simply positioning the shaft 60 vertical rather than horizontal, in bearing supports 63' and 64'. To change the direction of the drive 90° a gear box 73 of well known character is employed between the speed changer 57 and the coupling 58.

The preferred embodiment shown in Figures 4 to 6 differs somewhat from that previously described. The cam unit 41' in this form includes cams 41' and 42'. Followers 37' on the yokes ride the cam tracks. The pump element extension 35' is here in the form of a yoke having bearing portions 74 and 75 at the opposite ends and a bifurcated yoke portion 76 between. The bearing portion 74 is guided at 53 on the housing as in the other form, while the opposite bearing portion 75 is guided in the opposite end of the housing at 77. A chamber 78 is provided at the outer end of the housing to leave room for the end of the yoke.

In this form the cam unit extends through openings 80 in the yokes. Thus as best seen in Figures 4 and 6, the spacers 45 are within the yokes, whereas the cams are outside the yokes and the worm wheel is between the yokes.

A great advantage of this arrangement is that the entire cam unit can be assembled with the yokes outside the housing and then can be inserted bodily in the housing through the removable end portion 81 of the housing, thus greatly facilitating the assembly.

The drive in the form of Figures 4 to 6 is positioned on the pump housing as in Figure 3. In this form a variable speed motor device 56' is mounted on the housing and drives to a gear 82 on a suitable shaft 83 supported in bearings

84. The stub shaft connects to a dog type clutch 85. The other end of the dog type clutch 85 connects to a shaft 60' which forms a part of a worm assembly. A flanged bushing 86 surrounding the shaft 60' fits in an opening 87 of an arm 88 extended inwardly from the housing. The opposite end of the shaft is journalled at 90 on an arm 91 from the housing. The worm 61 on the shaft engages the worm wheel 44. Spacers 92, 93 and 94 surround the shaft 60' on the opposite sides of the worm and a thrust bearing 95 is located at the end of the shaft adjoining the arm 91 to take the thrust load.

It will be evident that the worm shaft, the worm, the bushing, thrust bearing and spacers can be removed bodily by taking off the cover portion 96 of the housing and removing a screw 97 which holds the flanged bushing in place. As shown in Figure 1, the cam shaft may be entirely enclosed and entirely internal. However, in Figures 4 and 6 the cam shaft is shown extending outside the housing at 98 to suggest that if desired individual housings could be interconnected and interdriven by this shaft. Of course if this were to be done the shaft would cease to be stationary, and would be suitably connected to the cam unit in any suitable manner not shown in the drawings.

Figure 7 illustrates that the number of pumps employed may not be limited to any particular number. In this form there is a drive 56^2 interconnecting by a gear train 100 with several variable speed units 57', 57^2 and 57^3 each of which operates a constant delivery pump 101, 102 and 103. A mechanical interconnection of drives assures an accurate proportioning of the several flows from the several units. The several pumps may operate on common suction or common discharge or on individual suction and individual discharge or any combination thereof to give the desired results. Each volumetric flow will then be in a definite ratio to each other volumetric flow as may be desired, regardless of change of speed of the prime driver.

Where a variable speed motor device is to be used, it can of course be a variable speed direct current motor of any well-known type commercially available. It is, however, preferable in most cases to employ a variable speed direct current motor with power from an alternating current source. Such devices are well known and a typical device of this kind is diagrammatically illustrated in Figure 8. One device of this character is known commercially as Thymotrol.

Transformer 104 has its primary connected to the alternating current source and its secondary tapped. The end taps 105 and 106 are connected to rectifier tubes (Thyratrons) 107, 108, 110 and 111 respectively. Opposite terminals of the tubes 107 and 110 are connected to one side of the armature 112 of a direct current motor 113. The other side of the armature of the motor is connected to the intermediate tap 114 of the secondary of the transformer. The opposite terminals of rectifier tubes 108 and 111 are connected to one side of the field 115 of the motor, the other side of the field being connected to the intermediate terminal 114. Each of the tubes is connected to electronic circuits 116 as well known in the art, and the starting, stopping and speed are controlled by a switch and regulator 117. The mechanism of Figure 8 is well known in the art, and it will be understood that any other suitable rectifier can be provided to operate a direct current motor.

In operation of any of the forms, it will be seen that once the device is assembled, it is merely necessary to vary the speed adjustment to obtain constant delivery at any output level. The particular type of speed changer used will vary widely to suit the individual installation. The type of arrangement shown in Figure 7 may be employed with particular advantage where a chemical reaction is involved and it is desired to supply several different chemicals by the pumps **101**, **102**, **103**, but to have the system independent of fluctuations in the electrical source.

It will be evident that in all of the forms shown there is a straight line relation provided between the motion of the pumping elements and the cams. Aside from the connection between the followers and the cams, there is no possibility of lost motion. The moving parts which accomplish the main operation are limited to the cam unit, the followers and the pumping elements with their extensions. Very little frictional loss can occur and maximum efficiency is obtained.

In making the cam corrections, allowance does not have to be made for complicated vectors as in other devices. Corrections can easily be applied to the cams for the different variables which may apply to the individual installation.

The structure is unusually rugged and even in case maintenance is required it can easily be performed. The wide spacing between the points of support of the cam shaft assures accuracy in the cam positions notwithstanding that slight wear may occur. The rear or outrigger bearing on the yoke assures accurate yoke alignment and elimination of any tendency of the yoke to whip or jump. The installation of the cam unit as a sub-assembly and the similar installation of the worm unit as a sub-assembly makes it possible to change these units readily at any time, as for example where it is desired to make an inspection, to replace worn parts, or to change the application of the pump to a different service, and therefore to use a different set of cams having different corrections.

The prase "common inlet and outlet," as used in the claims, is defined to include any case where the pumps draw from a common source and discharge into a common system, whether this is by means of manifolding at the pumps or by means of separate pipes to the source or system.

In view of our invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of our invention without copying the structure shown, and we, therefore, claim all such insofar as they fall within the reasonable spirit and scope of our claims.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is:

1. In a pump having constant delivery at any setting and variable delivery constant throughout the cycle at various settings, a plurality of pumps aligned side by side and each having an aligned pumping element in parallel relation facing in the same direction and having a common inlet and outlet, a yoke extending in prolongation and secured to each pumping element, having a bearing on either side of a bifurcated yoke portion, the bifurcated yoke portions being arranged side by side in the various yokes, a follower on each yoke having its center in a plane which includes the center lines of motion of the pumping elements, sliding bearing supports for the portions of the yokes at opposite ends of the bifurcated portions, a shaft extending through the bifurcated portions of the yokes, a cam unit comprising a cam for each follower and cooperating therewith, a gear between the cams, a bushing on the interior of the cam unit journaling on the shaft and connecting means extending through the cams through the bifurcated portions of the yokes and through the gear and uniting the same together to form the cam unit, a stationary cam shaft extending through the bushing, and having support at the opposite ends of the shaft on either side of the cam unit, a drive having a gear interconnected with the gear on the cam unit and a speed changer on the drive.

2. In a pump having constant delivery at any setting throughout the cycle and having variable delivery at various settings, a plurality of pumps having pumping elements aligned and extending in the same direction and having a common inlet and outlet, a plurality of yokes each extending in the direction of the line of motion of one of the pumping elements and connected thereto, each yoke having a sliding bearing portion at opposite ends of a bifurcated yoke portion, and the bifurcated yoke portion of the various yokes being arranged side by side, sliding bearings for the yokes engaging the bearing portions at opposite ends of the bifurcated yoke portions, followers on one side of each yoke having their centers in the plane which includes the lines of motion of the pumping elements, a cam unit extending through the interiors of the bifurcated portions of the yokes and rotatable on an axis in the plane including the lines of motion of the pumping elements transverse to such lines of motion, said cam unit including a cam operatively interconnected with each yoke, the cams being respectively out of phase and having corrections for one another to the extent that the delivery of the pump for any capacity is constant throughout the cycle, said cam unit also having a worm wheel interposed between the cams at a position between the yokes, and said cam unit having fastening means extending through the cams and the worm wheel and uniting the cam unit together as a single unit, a worm unit including a worm cooperating with the worm wheel, and including a shaft and removable bushings, the worm unit being removably mounted with respect to the worm wheel, and a support mounting the bushings for the worm unit.

ROBERT T. SHEEN.
ROYAL BARTLETT SAALFRANK.
JOHN W. WELKER.

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