Aug. 6, 1929. E. LUNGE 1,723,874

PUMP AND LIKE DEVICE FOR CONTROLLING THE RATE OF DELIVERY OF FLUIDS

Filed Nov. 13, 1925 4 Sheets-Sheet 1

Fig. 1.

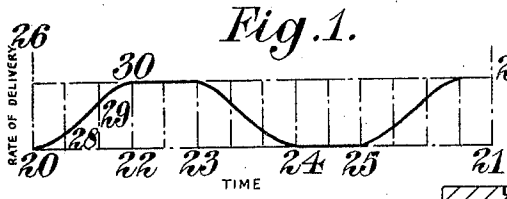


Fig. 13.

Fig. 11.

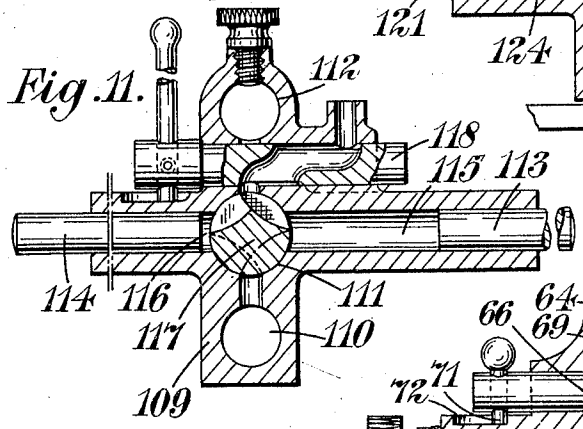


Fig. 5.

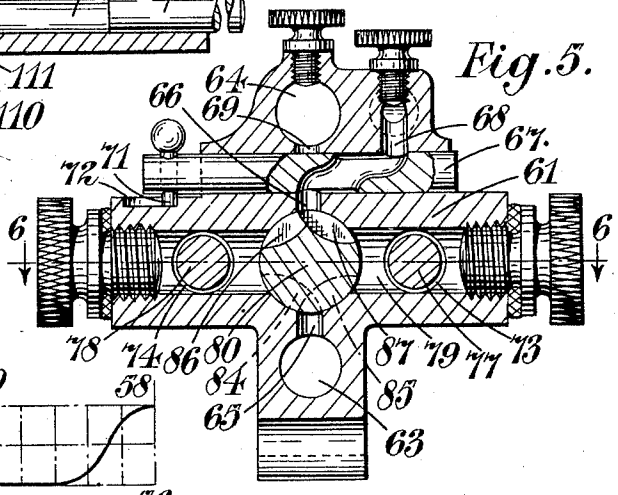


Fig. 2.

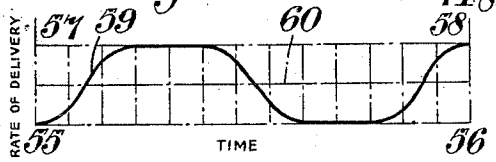
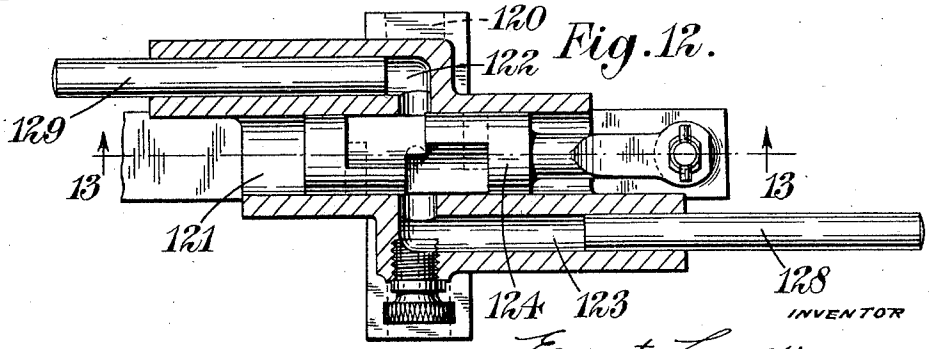


Fig. 12.



INVENTOR

Ernst. Lunge,

BY Watson, Cole, Morse & Grindle.

ATTYS.

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PUMP AND LIKE DEVICE FOR CONTROLLING THE RATE OF DELIVERY OF FLUIDS

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Fig. 3.

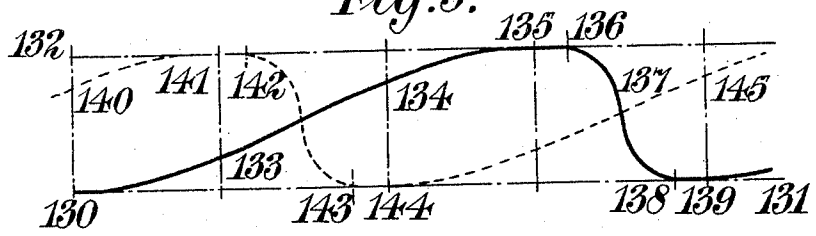


Fig. 4.

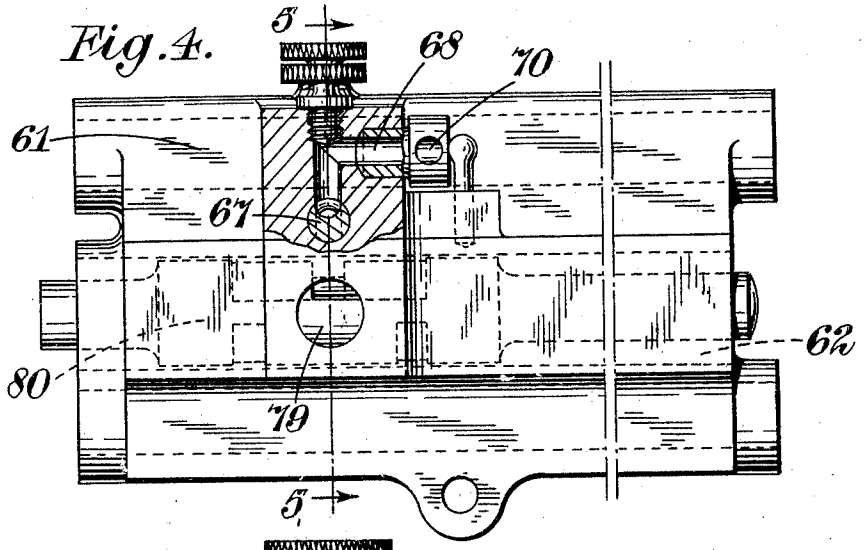
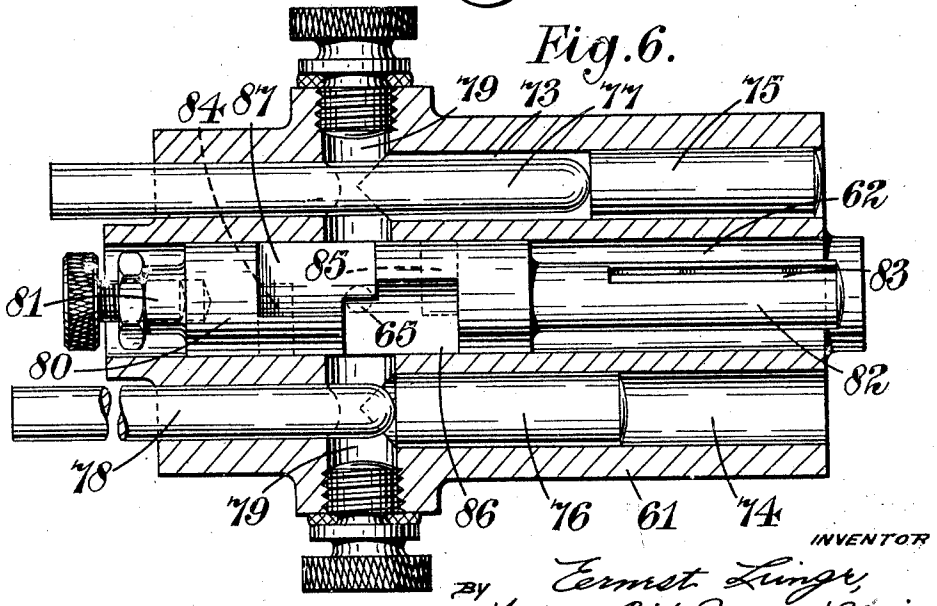


Fig. 6.



INVENTOR

BY Ernest Lunge,

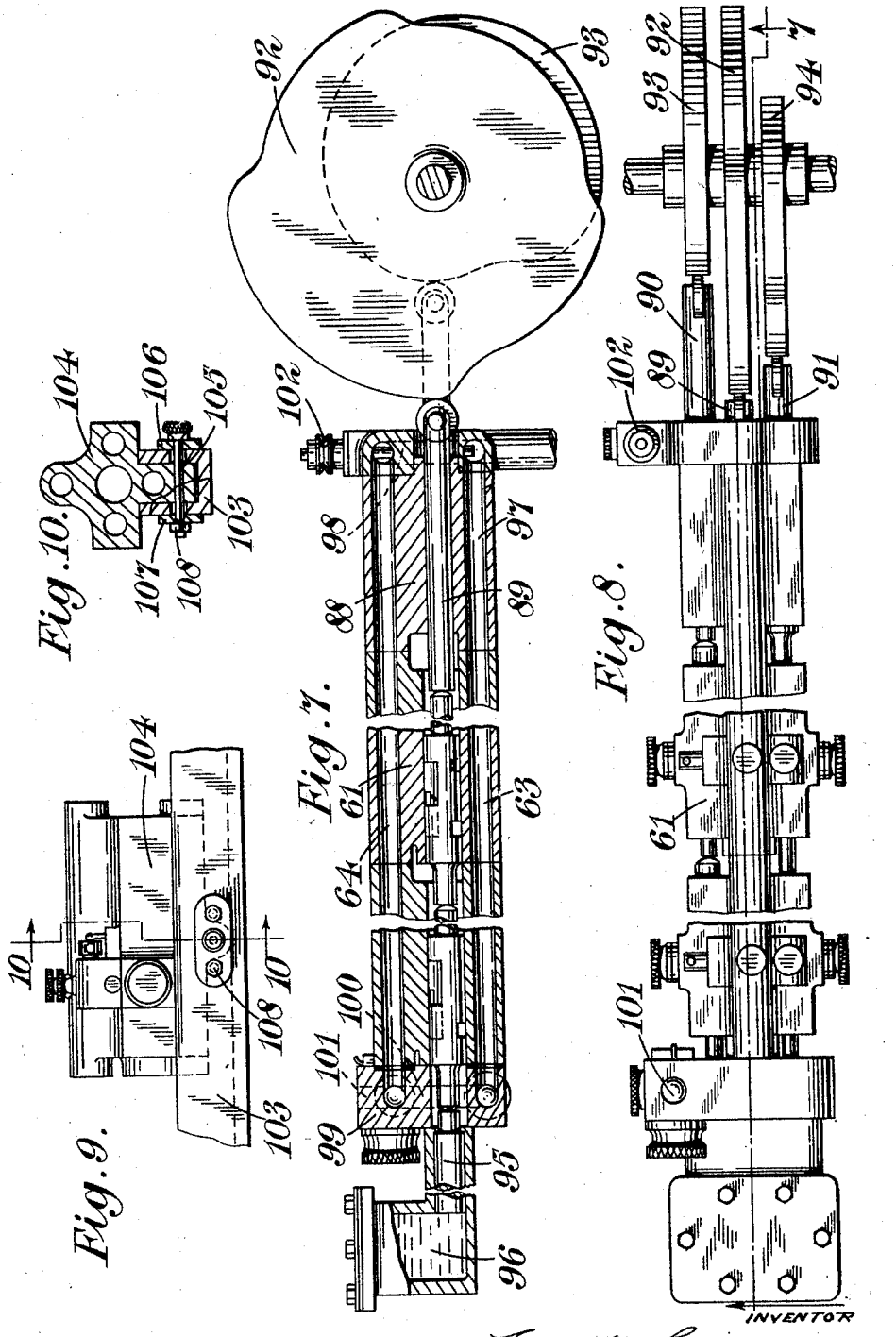
Watson, Coit, Morse & Grindle

ATTYS

Aug. 6, 1929. E. LUNGE 1,723,874

PUMP AND LIKE DEVICE FOR CONTROLLING THE RATE OF DELIVERY OF FLUIDS

Filed Nov. 13, 1925 4 Sheets-Sheet 3



Ernest Lunge,
By Watson, Cole, Morse & Grindle.
Attys.

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PUMP AND LIKE DEVICE FOR CONTROLLING THE RATE OF DELIVERY OF FLUIDS

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Fig. 14.

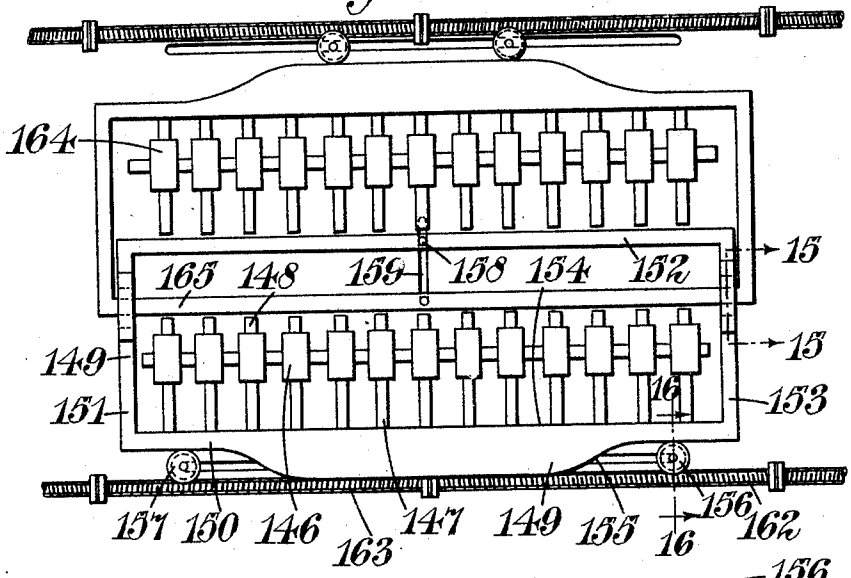


Fig. 15.

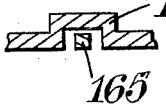
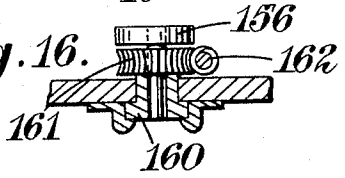


Fig. 16.



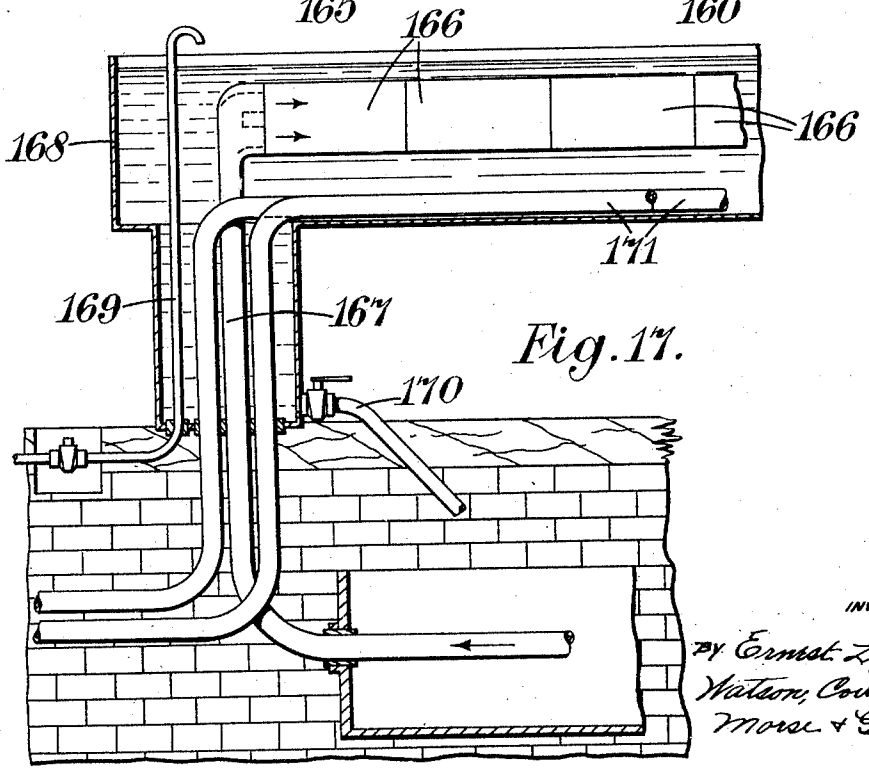


Fig. 17.

INVENTOR

By Ernest Lunge,
Watson, Cole,
Morse & Grindle.
ATTYS.

Patented Aug. 6, 1929. 1,723,874

UNITED STATES PATENT OFFICE.

ERNEST LUNGE, OF LONDON, ENGLAND, ASSIGNOR TO COURTAULDS LIMITED, OF LONDON, ENGLAND, A BRITISH COMPANY.

PUMP AND LIKE DEVICE FOR CONTROLLING THE RATE OF DELIVERY OF FLUIDS.

Application filed November 13, 1925, Serial No. 68,872, and in Great Britain November 20, 1924.

This invention is for improvements in or relating to pumping apparatus, and has for its object to provide an improved construction of the same, whereby among other advantages, an unvarying rate of delivery can be obtained. This feature is of particular importance in the manufacture of artificial silk, in which one of the operations consists in squirting a spinning solution from a fine nozzle in the form of a filament; in order to produce a satisfactorily uniform product, it is necessary that the nozzle should be continuously supplied with a spinning solution at a uniform rate or pressure. It is desirable that the supply should be a continuous one, as distinct from one in which a uniform pressure is attained by using large reservoirs or the like, and it is therefore necessary to provide a pumping apparatus which shall deliver the solution at a substantially uniform pressure or rate.

Any ordinary form of reciprocating pump has a discharge which fluctuates and which consequently varies in pressure and velocity from moment to moment; the extent of the fluctuations of pressure and velocity can be reduced by using several pumps all delivering into a common collector which supplies the squirting nozzle or nozzles, the pumps being so arranged that their delivery strokes are out of phase with one another. For example, three single-acting plunger-pumps can be actuated by cranks set 120° apart, and in this case, although there will still be fluctuations in the common delivery, such fluctuations will be of much less magnitude than those of the discharge of any one of the pumps. But this method, even with the customary use of air vessels on the delivery main, merely reduces the fluctuations in extent and does not eliminate them.

It is an object of the present invention to provide a pumping apparatus so constructed as to eliminate the fluctuations of velocity or pressure in the delivery main, which proceed from a plurality of reciprocating pumps or other pumps which are like them in that the discharge of an individual pump is intermittent or fluctuating, more nearly than has heretofore been practicable, and without the use of air vessels.

The present invention, therefore, comprises in pumping apparatus, the combination with a pump or pumps having a cyclically-fluctuating rate of delivery, of a cam-actuated additional pump, the actuating cam of which is characterized in that it is given a shape determinable from the delivery curve of the companion pump or pumps, and is used to operate its own pump at a fluctuating rate producing a delivery from that pump such that it counteracts, by its own departures from uniformity, the departures from uniformity that occur in the rate of delivery of the said companion pump or pumps, the complete apparatus being further characterized in that the delivery passages of the plurality of pumps as above set forth are distinct from one another and each passage is appropriated to one end of a pump-cylinder and is arranged to deliver "in parallel" with the companion passages to a chamber common to all of the pumps.

According to another feature of this invention, a viscose-pumping apparatus comprises the combination with a pump or pumps having a cyclically-fluctuating rate of delivery, of a cam-actuated additional pump, the actuating cam of which is characterized in that it is given a shape determinable from the delivery-curve of the companion pump or pumps, and is used to operate its own pump at a fluctuating rate producing a delivery from that pump such that it counteracts by its own departures from uniformity, the departures from uniformity that occur in the rate of delivery of the said companion pump or pumps.

This invention further comprises the combination with a pump that is to be used in combination with another pump or pumps having a cyclically-fluctuating rate of delivery and that is actuated by a cam calculated as aforesaid to give a uniform rate of delivery for the group of pumps, of a delivery-valve which controls the conduit leading from the pump towards the common outlet of the plurality of pumps, the valve being of the kind which in its opening and closing movements does not alter the cubic content of the pump charge, and a valve-operating mechanism that is actuated by the pump-gear during pauses which occur between the working-strokes of the pump-piston.

This invention also comprises certain details of construction and arrangement of pumps as hereinafter described with reference to the accompanying drawings in which—

Figure 1 is a graph showing the variations in the rate of delivery of a pump or group of pumps;

Figure 2 shows a delivery curve for each of the two similar cam-operated pumps which mutually counteract the variations in the rate of delivery of the other;

Figure 3 is a graph showing the relation between the total delivery of a pump or its piston displacement, and time;

Figure 4 is an elevation partly in section of a pair of pumps constructed in accordance with this invention;

Figure 5 is a transverse section on the line 5—5 of Figure 4;

Figure 6 is a plan in section on the line 6—6 of Figure 5;

Figure 7 is an elevation in section showing a group of pumps as illustrated in Figures 4 to 6, and the arrangements for driving them;

Figure 8 is a plan of Figure 7;

Figures 9 and 10 are a side elevation and a transverse sectional view showing the manner of mounting the pump units;

Figure 11 is a sectional elevation showing a modified construction of pump;

Figure 12 is a plan in section of another construction of pump;

Figure 13 is an elevation in section on the lines 13—13 of Figure 12;

Figure 14 is a more or less diagrammatic view in plan showing a method of driving the pumps;

Figure 15 is a section on the line 15—15 of Figure 14;

Figure 16 is a section on the line 16—16 of Figure 14; and

Figure 17 is a part diagrammatic view in sectional elevation showing the arrangement of the pumps in a bath of lubricant.

Like reference characters indicate like parts throughout the drawings.

Before describing in detail the construction of pumping apparatus in accordance with this invention, the method of determining the shape of the cam for driving the additional pump above mentioned will first be described.

Figure 1 shows a graph or curve plotted on a horizontal base-line 20, 21 which represents to a uniform scale the effluxion of time, and the ordinates indicate by their height the rate of delivery of the pump at any instant. The curve is drawn of an arbitrary shape such as might be met with in practice. It will be seen that the delivery of the pump commences at the point 20 on the time-base and the rate of delivery increases to the time 22, and then remains uniform during the period of time indicated by 22, 23. The rate of delivery then diminishes and becomes zero at the time 24. The suction period of the pump is indicated at 24, 25, when the delivery-curve of course remains at zero. The cycle then recommences in exactly the same form. In this particular curve, the delivery-period 20, 24 is considerably longer than the suction-period 24, 25, or, in other words, the pump has a slow delivery-stroke and a rapid return- or suction-stroke. Furthermore, it will be appreciated that the accelerating and diminishing rates of delivery are represented by curved portions of the graph, since the mechanical driving of the parts renders it desirable to avoid abrupt or sudden changes in movement or rate of movement.

The object of this invention is to provide a uniform delivery rate from the nozzle fed by this pump, and this will conveniently be selected as being equal to the maximum rate of the delivery of the pump during the period 22, 23; this total uniform rate of delivery will then be represented by the straight horizontal line 26, 27.

The total delivery from the pump during any specified time is measured by the area enclosed between the curve of its delivery rate, and the time-base, that is to say, the total delivery of the pump during the time 20, 22 is represented by the area 20, 28, 29, 30, 22, 20, and similarly during any other period of time. If the total delivery is to be at a uniform rate represented by the graph 26, 27, it is clear that if one pump delivers a quantity represented by the area between the curve 20, 29, 30, and the base-line 20, 21, there must be a second pump which will give a delivery indicated by the area above the curve 20, 29, 30, between that curve and the horizontal line 26, 30, so that when these two deliveries are added together, the total is represented by the area 20, 26, 30, 22, which is a figure of uniform height.

It follows, therefore, that the curve 20, 28, 29, 30, referred to the line 26, 27 as a base, indicates the rate of delivery that is required from the additional pump, and the pump is therefore actuated by a cam whereof the profile is so shaped as to give this curve of rate of delivery.

In the preferred form of the invention, two pumps are used, and both are cam-operated by similar cams. This is most easily effected by setting out, as in Figure 2, upon co-ordinates 55, 56 and 55, 57, the desired uniform delivery-curve 57, 58. Within the area between the lines 57, 58 and 55, 56, there is drawn a convenient delivery-curve 59 which bears the same relation to the line 57, 58 as a base, as it does to the line 55, 56 as a base, or in other words, which is symmetrical about a line 60, parallel with and midway between the lines 55, 56 and 57, 58. The curve 59 constitutes the rate-of-delivery curve of one pump when referred to the base-line 55, 56, and also the rate-of-delivery curve of the co-operating pump when referred to the base-line 57, 58. Since the

curve 59 bears the same relation to the two base-lines 55, 56 and 57, 58, it follows that the cams for the two pumps are identical with one another, and their angular relationship is determined by the fact that the delivery-period of one pump is to start immediately the rate of delivery of the other pump starts to fall off.

It may be pointed out here that the design of the cams may be derived from a consideration of curves representing the relationship between total delivery (or displacement) and time, instead of rate of delivery and time, and such a curve is illustrated in Figure 3. The base-line 130, 131, represents to a uniform scale the effluxion of time, and the vertical line 130, 132 represents the displacement of the pump piston from its inner end, that is to say, lengths measured upwards from the base-line represent the amount which the piston has moved outwards on its delivery-stroke from the beginning thereof.

The curve or graph showing the displacement of the piston is illustrated as starting at 130, and in order that the action may be as smooth as possible, the curve at this point is tangential to the base-line 130, 131. The graph rises, slowly at first, but at a gradually increasing rate up to the point 133, where it is continued as a straight line, 133, 134, which is tangential to the curved part 130, 133. The piston, during the part 133, 134 is moving at a uniform velocity. From the point 134, the piston has to be slowed down, as it is approaching the end of its stroke, and the graph is again given a curved form 134, 135, this curve being such that the line 133, 134, is tangential to it at 134, and the line 132, 135, is tangential to it at 135.

From the point 135 the graph continues for a short distance to the point 136, parallel with the base line 130, 131; this represents a pause at the end of the delivery-stroke, when the piston remains stationary for a period during which the valves of the apparatus are adjusted to a new position. The return-stroke of the pump is made more rapidly, being represented by the curve 136, 137, 138 which is tangential at its ends to the line 132, 136 and the base-line respectively so as to give a smooth action and is otherwise a smooth curve. From 138 to 139, the graph is coincident with the base-line, giving a period during which the piston remains stationary at the inner end of its stroke whilst the valves are being readjusted.

The shape of the graph 136, 137, 138 for the return-stroke is determined only by such considerations as will give smooth mechanical working.

The corresponding graph for the companion pump is indicated at 140, 141, 142, 143, 144, 145, and is exactly similar but is displaced in phase from the graph 130, 134, 139. A shape of graph which gives suitable working is one in which the portions 130, 133, and 134, 135 are portions of parabolas adjacent their vertices. The portions 130, 133, and 140, 141 of the two curves are exactly similar to one another but inverted and reversed. Further, it will be seen that the return-stroke of each pump takes place during the period whilst the other pump is moving at a uniform rate in the middle portion of its delivery-stroke.

A particular construction and arrangement of installation comprising pairs of cam-operated pumps, which are suitable for pumping viscose or like liquids, will now be described with reference to Figures 4 to 10 of the accompanying drawings.

The body 61 of the device is preferably a casting with various passages bored through it from end-to-end, of which a central uniform bore 62 accommodates a controlling-valve. At the bottom and top there are bores 63, 64 respectively which constitute a supply-pipe and a return-flow-pipe for the liquid; the supply-pipe 63 communicates with the valve-chamber by means of a vertical bore 65, and the valve-chamber opens by a vertical bore 66 into a transverse bore which contains a manually-adjustable valve-member 67. This member is capable of movement along its axis, to the left in Figure 5, so that communication can be established from the passage 66 aforesaid, either to the outlet 68 or to a vertical bore 69 which communicates with the return-flow-pipe 64. The outlet passage 68 is extended in any convenient manner, for example, as shown in Figure 4, to an outlet 70 whereto the spinning-nozzle can be connected when the apparatus is used in the manufacture of artificial silk. The valve-member 67 is limited in its movements by a pin 71 engaging a slot 72 in the body of the device. This prevents rotation of the valve or other movement into an inoperative position.

The pump cylinders are constituted by longitudinal bores 73, 74 respectively, (see Figure 6) which contain plungers 75, 76, these plungers being a close sliding fit therein. These plungers are operated by push-rods 77, 78 which extend through openings of a suitable diameter into the pump-chambers respectively where they engage by their rounded ends the plungers aforesaid. The pump-chamber in each case is constituted by the annular space surrounding the push-rods 77, 78 which are of less diameter than their corresponding plungers 75, 76.

The pump-chambers communicate each with the valve-chamber 62 by means of an opening 79 (Figures 5 and 6) bored transversely through the body 61 from front to back.

The valve controlling these two pumps is a cylindrical plug 80 fitting accurately in

its bore 62 and provided with extensions 81, 82 respectively (Figure 6) projecting from the two ends of the pump-body for operation by any convenient means. The part 82 is provided with a longitudinal slot 83 which is engaged by a pin in the casing for the purpose of preventing the valve rotating into an inoperative position. The valve-body 80 is provided with recesses 84, 85 which can put the supply-passage 65 alternatively into communication with one side or other of the transverse bore 79 and therethrough with one or other of the pump-chambers 73, 74. These two recesses are so situated that they come into operation alternately, and both can not be simultaneously in use.

The valve is also provided with two other recesses 86, 87 respectively, whereby the pump-chambers can be put in communication with the outlet-pipe 66. These two recesses extend longitudinally along the valve for a greater length than the inlet-recesses 84, 85, and they overlap one another longitudinally as shown most clearly in Figure 6, so as to permit of communication being established simultaneously from both pump-chambers to the outlet.

It will be seen that all the passages and chambers in the pump are formed as straight-through bores, the ends being closed where necessary by removable plugs. This construction greatly facilitates the cleaning and maintenance of the device and at the same time renders the machining operations simple and the construction therefore inexpensive.

The operation of this device is as follows. The pistons 75, 76 are reciprocated by cam-mechanism constructed in the manner described with reference to Figure 3. The piston 75, in the position illustrated in Figure 6 has just commenced its delivery at its maximum rate and the piston 76 has just stopped delivery. The valve 80 is now moved towards the right in Figure 6 so as to bring the recess 84 into alignment with the passages 79 and 65. The outlet recess 86 is thereby shut off from communication with the outlet 66 and is also shut off from the cross passage 79. The outlet recess 87, however, still provides communication from the cylinder 73 to the outlet. As soon as the valve has completed this movement, the piston 76 makes its rapid return-stroke towards the right in Figure 6; on the completion of this stroke, during which a fresh charge is drawn in from the supply-pipe 63, the piston pauses again, and the valve 80 is moved back to the position shown in Figure 5. The piston 75 thereupon slows down and simultaneously the piston 76 commences its delivery-stroke so that they are both delivering simultaneously, the total amount delivered being such as to maintain the desired uniform rate of delivery. This continues with the piston 75 slowing down until it stops, having reached the end of its delivery-stroke, and the piston 76 is delivering at the maximum rate. The piston 75 pauses whilst the valve 80 is moved to the left in Figure 6 so as to open communication from the supply-pipe 63 to the cylinder 73 through the recess 85. The piston 75 then makes its rapid return- or suction-stroke and pauses at the end thereof, and during this pause the valve is brought back again to the position illustrated in Figure 6. Meanwhile the piston 76 has been maintaining the full delivery at a uniform rate. When the piston 75 starts its delivery-stroke, the motion of the piston 76 slows down, so that their joint delivery is at the desired uniform rate. The piston 76 then reaches the end of its stroke and stops, and this completes the cycle, the various parts having now returned to the position illustrated in Figure 6 from which they started. This cycle of operations is repeated continuously, so that a perfectly uniform rate of delivery from the outlet is obtained.

It will be appreciated that pumps may be constructed in various ways in accordance with this invention, and the particular arrangement illustrated wherein the pistons and valves move endwise, is selected so that a number of pump-units can be assembled together as shown in Figures 7 and 8, and all operated simultaneously by a single driving mechanism. Referring to these figures, it will be seen that a number of the pump-units are arranged end-to-end in alignment with one another, each moving part of each unit abutting endwise the corresponding moving part of the next unit and operating it. The supply-pipe 63 and the return-flow-pipe 64 similarly align with one another to provide a channel extending throughout the whole length of the series of pumps. At the end of the series, a special unit 88 is provided to serve as a guide for plungers 89, 90, 91 which are aligned with the valves and pistons respectively. These plungers are provided with rollers whereby they engage each an operating cam 92, 93, 94, respectively, so that rotation of the cams causes an endwise movement of the plungers and of the corresponding parts of the whole series of pumps. At the other end of the series, the various moving parts abut the plungers 95 of a hydraulic or other suitable yielding pressure-device 96 which effects the return-strokes of the various parts, these strokes being of course governed by the profile of the cam. It will be appreciated, however, that the invention is not limited to this particular construction of pumps, for each pair of pumps could be actuated by its own cams, if so desired.

The viscose, or other liquid, is supplied to the series of pumps through a pipe-connec-

tion 97 (see Figure 7) which communicates with a body-portion having passages registering respectively with the conduits 63, 64, and which also has a connecting-passage 98 extending between said conduits. At the other end of the series a separate unit 99 is provided with a similar connecting-passage 100, and conveniently this passage also communicates with a valve-controlled outlet 101, situated at the highest part of the system. In the passage 98 aforesaid there is provided a screw-propeller or other pumping device, whereby the liquid in the conduits 63, 64 can be continuously circulated during the operation of the pumps in order to ensure homogeneity of the material supplied to the various pumps. When starting up such a series of pumps, the viscose or other liquid is allowed to flow in through the inlet 97 so that it fills the conduit 63 and rises through the connecting-passages 98, 100, and then fills the passage 64. Any air in the system is driven out by the rising liquid through the outlet 101 whereof the valve is kept open until the liquid flows out of it. It is thereby ensured that no air is permanently entrapped in the circuit and the pumping device in the conduit 98, which device is driven for example by the pulley 102, can be started, and then the cams can be set in operation to drive the pumps in the manner hereinbefore described.

When a number of pumps are assembled end-to-end in the manner illustrated in Figures 7 and 8, any suitable packing may be provided to ensure the joints of the conduits 63, 64 being tight, and the various parts are made of such length that the assembly is automatically correct. An elastic or yielding packing may be used so as to permit a reasonable tolerance in the fitting together of the various parts. Provision may be made if so desired, for adjusting the length of any of the moving parts as illustrated on the end 81 of the valve-member in Figure 6, to compensate for variations in workmanship, or accumulations of tolerance, which might affect the setting of the various parts.

The method of securing the pumps to the bench is illustrated in Figures 9 and 10. A channel-section rail 103 is secured on the bench, and the pump-bodies 104 are so shaped as to fit into it. Holes are bored through the side-walls of the channel to give a substantial clearance to the pins 105, and these pins are a close fit in locating-plates 106, 107. The pins are also a good fit in the body of the pump. When the various pumps are first assembled, they are accurately aligned with one another, and the pins 105 inserted, with the plates 106, 107 loose. The plates 106, 107 are then locked in position, as by the bolts 108, so that the position of any pump-unit is accurately determined. By simply withdrawing the pin 105 the pump-body can be removed for inspection or cleaning, and when it is replaced, it has only to be aligned, so that the pin 105 can be inserted, and it is then assured that the pump is properly aligned with the other units.

Pumping devices in accordance with this invention may be constructed in various ways, and Figure 11 illustrates a modification. In this case the pump-cylinders are arranged transversely to the valve-chamber. The pump-body 109 is provided with three bores 110, 111, 112 extending longitudinally through it and serving respectively as the supply-pipe, the valve-chamber, and return-flow-pipe. The two pumps are constituted by plungers 113, 114 reciprocating in transverse bores 115, 116 respectively, which communicate with the valve-chamber 111. The valve 117 is of the same construction as that previously described, as also is the outlet with its controlling valve 118. It will be seen that this construction of pump can be made of a smaller length, measured along the length of the supply-pipe, than the construction previously described, so that a larger number of units can be assembled on a given length of bench. The pistons of each pump project transversely from the line of the row of pumps and they may be operated in any convenient manner, as for example, by the mechanism illustrated in Figures 14—16.

Referring to these drawings, a number of the pumps or like devices for controlling the rate of delivery of the liquid are arranged side-by-side as indicated diagrammatically at 146 with their pistons projecting transversely from the line of pumps as indicated at 147, 148.

A rectangular frame 149 surrounds the group of pumps and is constituted by four frame-members 150, 151, 152 and 153. The member 150 at the front is arranged to bear by its rear edge 154 against the pistons 147 of the group of pumps, and its front edge 155 is formed with the cam-surface whereof the shape is predetermined according to the movement which is to be imparted to the plungers or pistons 147.

To co-operate with the cam-surface 155 there are provided two rollers 156, 157 which are mounted as shown in Figure 16 in such a manner that they can be traversed in a straight line longitudinally of the frame-member 150, so that the frame is moved in accordance with the contour of the cam 155, and in so doing moves the plungers 147. A pin 158 is secured on the underside of the frame-member 152 and engages a straight slot 159 to constitute a guide for the frame 149, so that the frame is supported and guided in its operative movement at three points, namely, by the rollers 156, 157 and by the pin 158.

Each of the rollers 156, 157 is mounted as shown in Figure 16 in a carriage or slide block 160 which can slide in a slot in the base-plate. Each roller also has mounted on its spindle a gear-wheel 161 which engages a screw-threaded spindle 162 which is rotated at a uniform speed. The rotation of the wheel 161 received from the spindle 162 causes the roller 156 to roll on the surface of the cam 155 and thereby traverses the roller along it. The roller 157 is similarly operated, and its screw-threaded spindle 163 may be oppositely-handed from the spindle 162 so that the two spindles can be coupled together and rotated in one direction to cause the two rollers to approach one another, and rotated in the opposite direction to cause them to recede from one another.

A second group of pumps may be arranged as shown at 164 back-to-back with the first group 146, and operated by a similar mechanism at the other side of the bench. In this case the rear frame-member 152 may be used to operate the plungers of the second group on their reverse stroke, and similarly, the rear member 165 of the second frame can operate the plungers of the first group on their rearward stroke. With this arrangement it is not necessary to use pumps in which the plungers or pistons are moved outwards by the pressure of the fluid supply as above mentioned. Furthermore, with this arrangement the side-frame-members are cranked as shown in Figure 15 at 153 in order to clear the other frame-members and permit the desired relative movement of the frames.

Any desired number of groups of pumps may be arranged along a bench and the screwed operating-spindles of all the groups may be connected together and driven by a single motor at the end. The operating mechanism is thereby simplified and considerable economy in space is effected. It will be seen that the features of simplicity of construction and facility for cleaning and maintenance are provided in this construction with transverse pistons, as in the previously-described construction.

In order to make clear the great flexibility of design which is possible with pumps in accordance with this invention, yet another construction is illustrated in Figures 12 and 13. In this case, the supply- and return-flow-pipes are indicated at 119, 120 respectively, and the valve-chamber 121 is arranged with its axis transverse to that of the supply-pipe. The pump-cylinders 122, 123 are arranged in the same horizontal plane as the valve chamber, one on each side of it, parallel with it, and extending in opposite directions from the centre-line of the supply- and return-flow-conduits. The valve 124 is reciprocated by any convenient mechanism, such for example, as a moving frame 125 underneath the pump, having an upstanding lug 126 to receive a pin 127 engaged with the end of the valve-stem.

The other details of construction need not be described in detail, for it will be obvious that they may be varied within very wide limits without departing from the scope of the invention as set forth in the appended claims.

It will be appreciated that when a number of pumps as above described are assembled in a group and all driven by the same mechanism, it may be desired to stop the delivery from one pump without interfering with that of the others, and it is for this reason that the by-pass valve 67 aforesaid has been provided. If the delivery from a pump is to be stopped, it is only necessary to adjust the by-pass valve so that the liquid delivered by it is delivered into the return-flow-conduit instead of to the outlet in the normal manner. Also, it should be noted that the type of controlling-valve which is used for these pumps is one in which the adjustment of the valve from one position to another does not vary in any way the cubic content of the charge or of the chambers within a pump. This is effected by providing recessed or notched members so that in normal working the recess is filled with liquid, and this quantity of liquid is moved bodily with the valve as it is moved from its open to its closed position, and vice versa. Moreover, the arrangement whereby the valve is operated whilst the pump-plungers are stationary is advantageous in that before a pump starts its delivery-stroke, the outlet-passage is fully opened so that there is no throttling of the flow of liquid which might tend to produce unknown variations in the rate of delivery.

A further feature of this invention relates to the lubrication of pumps and like devices as hereinbefore described. In the manufacture of artificial silk from viscose, when the solution is ready for spinning it is in a state in which it hardens on exposure to atmosphere and it is desirable that any such hardening of the solution on parts of the pump should be avoided, and Figure 17 illustrates diagrammatically an arrangement for obviating this difficulty. The pumps are immersed in a solution which prevents hardening of the viscose and also prevents corrosion of the pumps and associated parts themselves.

Referring to Figure 17, the pumps are indicated diagrammatically at 166, and they are supplied with the spinning solution through a pipe-connection 167. The pumps are mounted in a trough-shaped vessel 168 which is filled to a depth sufficient to sub-

merge them with a dilute alkaline solution, such for example as a 1% solution of caustic soda or a 1% solution of sodium carbonate. This may be supplied to the trough through a pipe 169 and a drain-cock may be provided at 170.

Means may also be provided for regulating the temperature of this bath, such for example as pipes 171 through which heating or cooling mediums may be circulated. Ethyl-chloride and hot water are suitable mediums, although many others may be used.

It is preferred to use an alkaline solution as above mentioned since it is available as a by-product in the process of manufacture and can readily be made of an appropriate strength for the purpose above mentioned. If caustic soda be used it is desirable that its strength should be not more than 1%, or alternatively not less than 10%, as the intermediate strengths are apt to cause a certain amount of corrosion of iron or steel. Sodium carbonate can be used, however, in any strength up to say 10% without objectionable corrosion occurring.

In order to prevent any contamination of the alkaline solution by sulphuretted hydrogen or other sulphur-bearing fumes or gases which may be present in the atmosphere, a thin layer of mineral oil or like material may be provided on the surface of the bath.

What I claim as my invention and desire to secure by Letters Patent is:—

1. In pumping apparatus, the combination of a cam-operated reciprocating pump, an operating cam therefor which is so shaped as to cause a pause in the operation at the end of each stroke of the pump, a second cam-actuated pump, an operating cam therefor which is so shaped that the combined delivery of the two pumps is constant at all times, and further that a pause in the operation is caused at the end of each stroke of the second pump, delivery passages from each of said pumps which are distinct from one another, each appropriated to one pump and arranged to deliver in parallel with the companion passage.

2. In pumping apparatus, the combination of a cam-operated reciprocating pump, an operating cam therefor which is so shaped as to cause a pause in the operation at the end of each stroke of the pump, a second cam-actuated pump, an operating cam therefor which is so shaped that the combined delivery of the two pumps is constant at all times, and further that a pause in the operation is caused at the end of each stroke of the second pump, supply and delivery passages for each of said pumps, valve means controlling said passages and a valve-operating mechanism which is actuated during the pauses which occur between the strokes of the pumps.

3. In pumping apparatus, the combination of a cam-operated reciprocating pump, an operating cam therefor which is so shaped as to cause a pause in the operation at the end of each stroke of the pump, a second cam-actuated pump, an operating cam therefor which is so shaped that the combined delivery of the two pumps is constant at all times, and further, that a pause in the operation is caused at the end of each stroke of the second pump, both of said cams being further so shaped that the maximum rate of delivery of each pump is maintained through an appreciable extent of movement of the cam, as distinct from being merely instantaneous.

4. In pumping apparatus, the combination of a series of plunger-operated pumps arranged in a row with their plungers disposed and movable crosswise of the row, a member mounted for movement in a single plane in which the pump plungers move extending lengthwise of the row in operative engagement with said plungers of all of the pumps, and means for moving said member in a direction transverse to its length for operating simultaneously all of said plungers.

5. In pumping apparatus, the combination of a series of plunger-operated pumps arranged in a row with their plungers disposed and movable crosswise of the row, a cam-member having a flat face opposite its cam face, engaging said plungers by said flat face, abutments engaging said cam face and means for traversing said abutments longitudinally of said cam face.

6. In pumping apparatus the combination of a plurality of cam-operated reciprocating-plunger pumps arranged in a row with their plungers disposed and movable crosswise of the row, a cam-surface mounted for movement in a single plane in which the pump-plungers move and extending lengthwise of the row in operative engagement with said plungers of all the pumps, a second plurality of cam-operated pumps similar to and co-operating respectively with said first mentioned plurality, said cam-surfaces being so shaped that the combined delivery of all the pumps is constant at all times and further that a pause in operation is caused at the end of each stroke of each plurality of pumps, and means for moving each cam-surface in a direction to operate simultaneously all of its associated plungers.

In testimony whereof I affix my signature.

ERNEST LUNGE.