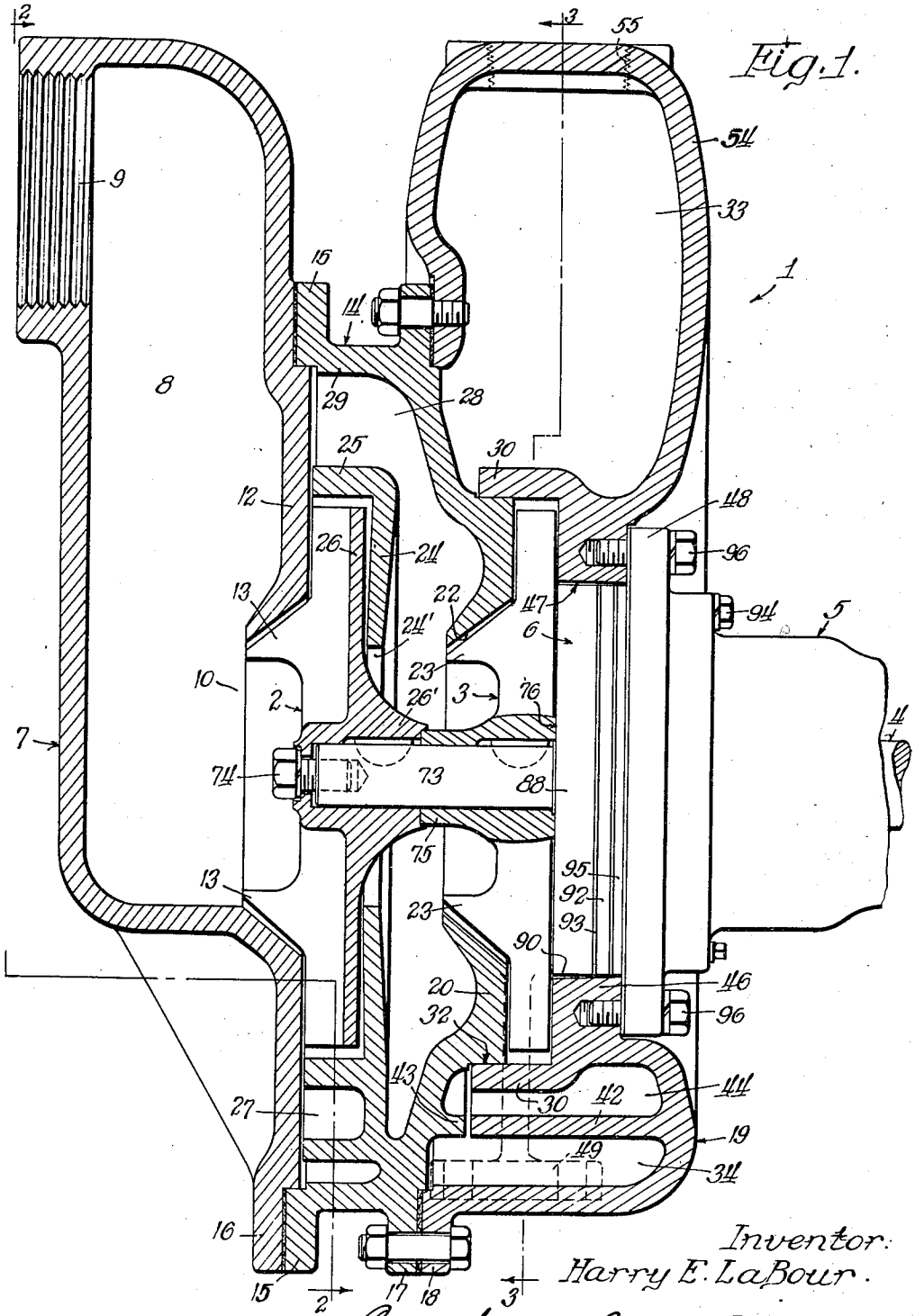
July 1, 1941. H. E. LA BOUR 2,247,709

PLURAL STAGE SELF-PRIMING CENTRIFUGAL PUMP

Filed May 31, 1938 4 Sheets-Sheet 1

Fig. 1.



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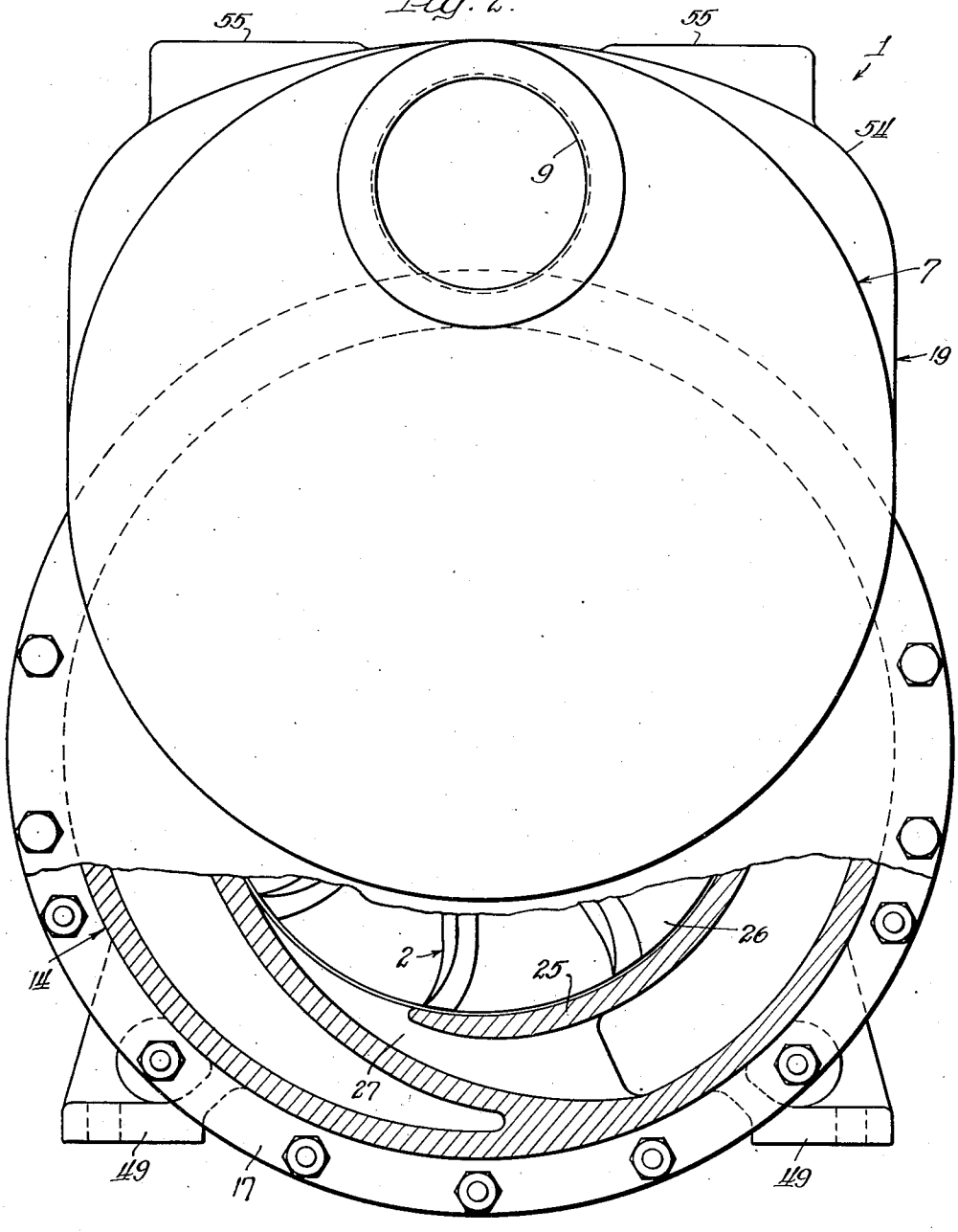
By Brown Jackson Boettcher & Dennis Attys.

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PLURAL STAGE SELF-PRIMING CENTRIFUGAL PUMP

Filed May 31, 1938 4 Sheets-Sheet 2

Fig. 2.



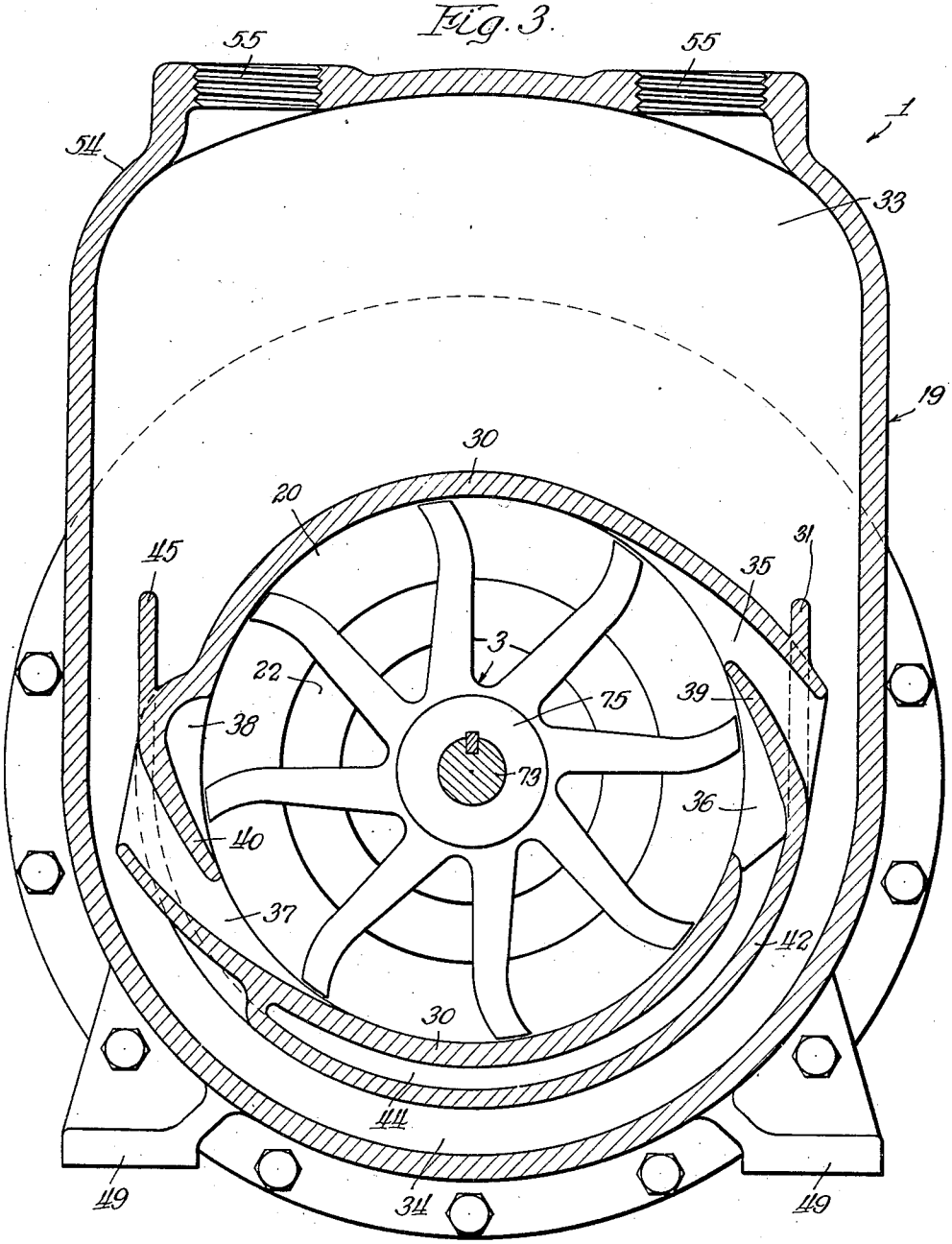
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PLURAL STAGE SELF-PRIMING CENTRIFUGAL PUMP

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Fig. 3.



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PLURAL STAGE SELF-PRIMING CENTRIFUGAL PUMP

Filed May 31, 1938 4 Sheets-Sheet 4

Fig. 5.

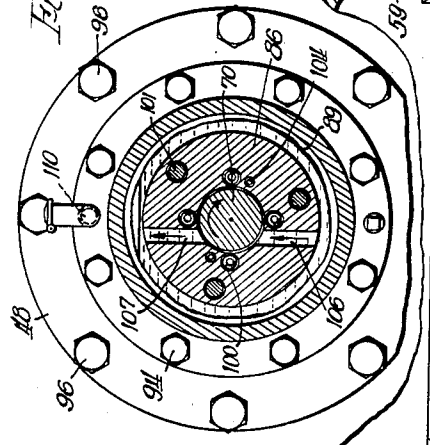


Fig. 4.

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Patented July 1, 1941 2,247,709

UNITED STATES PATENT OFFICE

2,247,709

PLURAL STAGE SELF-PRIMING CENTRIFUGAL PUMP

Harry E. La Bour, Elkhart, Ind.

Application May 31, 1938, Serial No. 210,804

13 Claims. (Cl. 103—113)

My present invention relates to self-priming centrifugal pumps. The application of the principle of self-priming of my prior Patent 1,578,235 to certain classes of work involving high or relatively high head delivery presents practical difficulties which it is the aim of the present invention to solve.

There has long been a demand for a portable self-priming centrifugal pump unit for fire-fighting service. While attempts have been made to supply this demand, the severity of the requirements and the expense of pumps designed to meet them have discouraged the production and general use of devices of this class.

Such a unit must stand for long periods unused and without attention. Particularly is this true for volunteer or non-professional service. The pump must be capable of delivering large volumes of water at pressures high enough to reach and be effective at the uppermost stories of buildings which it is to protect. The pump must be capable of drawing water from as low a source as possible and must be designed to withstand intake pressures from city fire mains and the like. The pump is also subject to being driven at the highest speeds that the driving motor can develop. In brief, the pump and driving motor, which usually will be a gasoline engine, will be subject to very severe usage or even abuse.

Size, weight, and cost are very important requirements in addition to demands for absolute reliability and effectiveness under all conditions.

I have conceived the possibility of introducing a small size, high capacity stage (centrifugal pump unit) between the inlet trap and the self-priming stage (centrifugal pump unit and separator) in such a manner that a number of important advantages are secured,—among others the following:

1. The pump may be made compact and of relatively low cost, while capable of self-priming and capable of high delivery at high head.

2. The loss of priming liquid is prevented or limited because the separator trap is at the delivery end of the second unit.

3. The first stage acts as a part of the intake trap for the second or self-priming stage.

4. All passageways which are not of large open character are subject to reversal of flow in the operation of the pump.

5. Neither unit acts as a brake upon the other during either self-priming or during liquid pumping.

6. During self-priming the anterior unit automatically reduces the load by substantially emptying itself of liquid. Hence it operates substantially only on air and does not absorb any substantial amount of power nor interfere with the operation of the posterior self-priming unit.

7. The self-priming unit acts as an air pump by the employment of the recirculation of the trapped charge of liquid but immediately upon obtaining a full complement of liquid it automatically stops the recirculation and the passageways or ways which previously served to return the recirculating priming liquid serve as additional outlet passageways or ways whereby the delivery of liquid is greatly enhanced.

8. By the provision of a small size built-in (self-adjusting) and self-lubricating packing of the pump shaft, the shaft has minimum overhang in respect to its supporting bearings.

9. By the use of a semi open type of impeller in the initial or anterior stage the necessity for sealing rings between stages is avoided. This is particularly important for handling gritty fluids.

10. By the provision of an oil-filled double seal between the pump and the bearings, not only is the seal greatly improved but the bearings are doubly protected, and failure of the first part of the seal gives an indication of incipient failure of the seal.

11. By utilizing a common wall for the oil reservoir of the seal and pump casing the oil is cooled by the liquid pumped and the circulation of oil in the seal insures cool running. Also, the mass of metal in contact with the oil gives ample radiating surface to keep the seal cool indefinitely, even if the pump be operated dry.

12. The construction is such that the bearings and frame need not be disturbed for disassembly of the pump and/or removal or renewal of the gland or shaft seal.

13. The bearings may conveniently be preadjusted and the pump parts conveniently assembled and disassembled.

14. The pump requires no close fit mechanically, hence may stand unused, and oxidation or corrosion, if it should occur on the working parts of the pump, would not disable the same.

15. No hand operations whatever are required. There are no valves, clutches, or controls, and hence unskilled attention or operation can do no damage.

16. Since the anterior stages automatically empty themselves of all but a minor part of the liquid upon starting priming, the pump may be operated on the priming phase for extended periods without overheating or other injury.

17. In the specific embodiment herein shown the pump holds up its pressure over a wide range of deliveries. This is particularly desirable on a fire pump, and particularly a twin hose unit.

Many of the above advantages and features may be independently utilized, as will be apparent to those skilled in the art.

I am aware that it has heretofore been proposed to provide a water ring circuit air pump in series or in parallel with one or more stages of a centrifugal pump. If the said air pump be disposed in series with the other impeller or impellers it entails a serious loss in power or capacity, or both, upon liquid pumping. If the air pump be in parallel it also involves a loss of efficiency on liquid pumping unless it be disconnected or drained. This involves mechanical difficulties and complications. Also, parallel operation involves the requirement of a closed outlet during priming; all of which is avoided by my present invention.

By my invention, as soon as liquid reaches the first stage a wet vacuum is at once brought into effect, and the second stage is almost instantly transformed into a full liquid stage. Hence, priming is performed very quickly and full delivery pressure is immediately thereafter available. This is of the utmost importance in fire extinguishing service.

Now in order to acquaint those skilled in the art with the manner of constructing and operating a device embodying my invention I shall describe, in connection with the accompanying drawings, a specific embodiment of the same. In the accompanying drawings, in which like reference numerals have been applied to like parts—

Figure 1 is a vertical longitudinal section through one form of pump of my invention;

Figure 2 is a front elevational view, partly in section, as viewed from the left in Figure 1 and with the lower part in section, as indicated, and on the line 2—2 of Figure 1;

Figure 3 is a vertical transverse section taken on the line 3—3 of Figure 1 and looking in the direction of the arrows;

Figure 4 is a horizontal section through the shaft seal and adjacent parts of the pump casing; and

Figure 5 is a section taken on the line 5—5 of Figure 4 and looking in the direction of the arrows.

The pump herein illustrated comprises four main parts, namely, the main housing 1 within which operates the rotating system, in this case consisting of the impellers 2 and 3 mounted on a common impeller shaft 4, the bearing support 5, which is rigid with the main casing 1, and the shaft seal 6.

The housing is divided up into three main portions, namely, the front section 7, which includes the intake trap 8 communicating through the threaded inlet opening 9 with the suction hose which is adapted to be connected thereto by a threaded coupling suitable for suction hose such as is employed in connection with fire extinguishing apparatus. The intake trap 8 has an opening 10 through a portion of the front section 7 which serves as the front plate 12 for the initial stage impeller, namely, the impeller 2. This front plate 12 has a flared opening which cooperates with the tapered winglike portions 13 of the impeller 2.

The intermediate section 14 of the main housing 1 has on its front side a mating flange 15 which cooperates with the flange 16 of the front section 7 to form a tight joint between the two sections 7 and 14. This intermediate section 14 likewise has a clamping flange 17 at its rear side cooperating with the clamping flange 18 of the third or main frame section 19. The intermediate section 14 provides a front plate 20 forming a part of an impeller casing for the final impeller 3. It has a flared inlet opening 22 cooperating with the wings or flared portions 23 of the said impeller 3.

The intermediate section 14 also has, preferably as an integral part of it, a back plate portion 24 cooperating with a peripheral wall 25 to complete the necessary parts for forming an impeller casing for the impeller 2.

It will be observed that the back plate portion 24 does not have any seal or fit with the rotating system. Instead, it has a relatively large opening 24' surrounding the shaft 4 of the rotating system. The impeller 2 is a semi-shrouded impeller, that is to say, the blades extend outwardly from the platelike disc 26 which is integral with the hub portion 26' fastened to the shaft 4. The blades themselves extend at right angles to the surface of the disc 26 and preferably are substantially straight blades with slightly curved tips, although this form of blade is optional. The peripheral wall 25, in the embodiment herein shown, has three tangential throats or outlets which interrupt the continuity of the cylindrical portion 25. The three outlets 27, 27, 27 form gradually expanding throats, as shown in Figure 2, leading into the space 28 which is defined by the peripheral wall 29 of the intermediate casing section 14. This peripheral space 28 communicates freely with the tapered inlet opening 22 of the second stage.

This space 28 at its periphery extends radially beyond the impeller casing 25 and at its central part communicates with the central inlet opening 22 of the second impeller casing. The result of this constriction is that even if the trap 8 is completely emptied of liquid upon starting the priming action, water will be trapped in the space 28 below the bottom of trap 8 and central inlet opening 22. This water tends to run back into the periphery of the first impeller through the throat 27 and assist the first unit in its expulsion of air into the space 28.

It is to be observed that the clearance between the back plate 24 and the shrouding 26 of the first impeller 2 expands radially outwardly slightly so that the deposit of solids therebetween will be prevented, the tendency being for them to clear themselves by the centrifugal effect and the outwardly tapered clearance space. The main frame section of the housing or casing 1 has a substantially cylindrical flange 30 which forms a peripheral wall for the impeller casing of the impeller 3. The front plate section 20 has a cylindrical piloting wall 32 which pilots the front plate portion 20 within the flange 30 to close the periphery of the impeller casing. The main frame section 19 comprises a hollow space forming the separator 33 the chief volume of which lies above the second impeller 3 but which communicates with an open space 34 below the impeller housing for the impeller 3. In brief, the separator space surrounds the impeller casing for the final stage. The housing section 19 is provided with walls such as the flange 30, 30 interrupted to provide the pairs of throats 35, 35 shown at the right of Figure 3 and the cooperating pairs of throats 37 and 38 shown at the left of Figure 3. The throats 35 and 37 are main

throats and are preceded in the direction of rotation by the cylindrical concentric portions **30, 30** to secure the desired development of pressure in advance of discharge. The throats **36** and **38** are auxiliary or priming throats which are adapted, during priming, to have liquid return peripherally into the impeller for the purpose of forming a mixture of liquid and gas which is discharged at the main throats **35** and **37**.

A wall **39** extending in substantially to the periphery of the impeller (with mechanical clearance) provides a cut-off or division between the throats **35** and **36**. Likewise, the wall **40** performs the same service between the throats **37** and **38**. It is to be understood that when the impeller **3** receives its full complement of liquid, liquid will be discharged through both pairs of throats and recirculation is stopped.

The cut-off wall **39** is extended into a substantially arcuate wall **42**, as will be seen more clearly in Figures 1 and 3. The arcuate wall **42** approaches the cooperating flange **43** formed on the intermediate wall section to define a channel or inner manifold **44** lying between the walls **30** and **42** and communicating at each end with the separator space **33** and with the outer manifold **34**. The wall **42** between the two manifolds **44** and **34** extends upwardly above the secondary discharge throat **38**, as indicated at **45**, to a point where the discharge from the main throats **37** and **35** is carried beyond the reentry point of liquid to the throat **38** during priming. Thus it will be seen that the main throats **35** and **37** project through the arcuate wall **44** in order to deliver their discharges into the outer manifold or channel **34** radially outside the inner manifold or channel **44**, the liquid driven by these main throats moving in a generally clockwise direction to a point beyond the end of the flange or wall **45**. The throats **38** and **36** communicate with the manifold or passageway **44** through which liquid tends to flow in a clockwise direction during both priming and liquid pumping.

The two main throats **35, 37** are shrouded at front and rear, so as to define tubular expanding passageways in which the desired conversion of velocity into pressure may take place before discharge into channel or manifold **34** takes place. The two auxiliary throats **36, 38** likewise provide expanding passageways for energy conversion, but they are arranged also for the function of admitting priming liquid back into the periphery of the impeller during priming.

The dividing wall **42** may extend upwardly on the right as indicated in dotted lines at **31**, the purpose being to prevent shunting of air laden liquid discharged during priming by throat **35** from direct entry into the priming throat **36** or the inner manifold or passageway **44**. Likewise, it is desirable that the priming throat **38** be guarded or shielded from shunting of gas laden liquid from throat **37** or in fact from manifold **44**.

The auxiliary throats **36** and **38** are fed with priming liquid which normally flows down at the right (in Figure 3) from the separator space **33**, some passing on clockwise and flowing in at the second priming throat **38**. It is to be observed (see Fig. 1) that the manifold **44** consists of a deeper part at the right and a shallower part at the left. The throats **36** and **38** lie within the shallow part, but also communicate with the deeper part of said manifold **44**. Thus while the flow of liquid is in the same direction in manifold **44** during both priming and discharge, it is to be observed that during priming gas freed liquid flows in at the right hand end of the manifold (see Fig. 3) while during liquid pumping the discharge of the throats tends to flow chiefly out of the left hand end of said manifold. Both ends of both manifolds thus communicate with the main separator space **33**. This specific arrangement is capable of considerable modification in detail.

The auxiliary throat **36** is shrouded on the sides to produce during liquid pumping a divergent passageway in which adequate conversion may be secured in advance of discharge into the manifold **44**. The details of this construction are subject to variation. The auxiliary throat **38** opens at one or both sides into the manifold **44** near its left hand end as viewed in Figure 3. The desideratum is to avoid during priming shunting of air laden liquid into said throat. The specific arrangement of throat **38** is also subject to variation.

It is to be understood that instead of two pairs of throats, a single pair might be employed, or three pairs might be employed if desired. Also, it is to be understood that for the priming operation a single large throat may take the place of a pair of throats and that the structure shown in my copending applications, Serial No. 118,032, filed December 29, 1936, which has matured in Patent No. 2,166,338, and Serial No. 175,187, filed November 18, 1937, which has matured in Patent No. 2,184,349, may be employed instead of the specific form shown in Figures 1 and 3. Also, it is to be understood that the connection of two or more pairs of throats may be made as shown in my prior Patent No. 2,110,883.

The main housing section **19** provides also a back plate portion **46** for cooperation with the cylindrical peripheral wall **30** and the front plate **20** for forming the impeller casing for the final stage of the pump. This back plate portion **46** is apertured to provide a fairly large cylindrical opening **47** therethrough.

The bearing housing **5** has a flange **48** which cooperates with the back cylindrical wall of the back plate portion **46** to hold the bearing housing **5** rigidly to the main frame portion **19**. The main frame portion **19** is provided with supporting feet **49, 49** shown in Figure 3, these feet being adapted to rest upon a suitable chassis frame of a portable support, such as a cart or wheeled vehicle. Likewise, the rear end of the bearing housing **5** is provided with a foot or pedestal **50** which is adapted to rest upon a cross frame member **52** (see Figure 4) resting upon the longitudinal sills of the truck frame or other foundation. In the embodiment shown, the bearing housing **5** has an annular clamping space **95** to which there is adapted to be clamped an outer flange part of the shaft seal **6** which is later to be described.

The separator body **54** which defines the separator chamber or space **33, 34** has a pair of outlet openings **55, 55** each threaded for standard fire hose coupling connection. Obviously, if pipe connection is to be made to the separator chamber **54**, as in a permanent installation, a single opening or outlet may be provided, or alternatively, a pair of openings each large enough for the full discharge may be provided and one of the same be normally plugged as by a removable pipe plug.

The bearing supporting housing **5** comprises generally a main tubular portion extending lon-

gitudinally of the shaft 4. At its outer end it is closed by a cap 57 which cap is held by cap screws 58. The outer ring or race of a radial ball bearing 59 is free to float axially in either direction, but is supported radially. The inner race of the ball bearing 59 is secured against axial motion on the shaft 4 between a pair of stationary shoulders fastened on the shaft 4. This ball bearing 59 is adapted to carry radial load only. A second ball bearing 60 is disposed near the inner end of the housing 5, the outer race being disposed in a cylindrical seat terminating in the shoulder 62 whereby displacement of the outer race to the right as viewed in Figure 1 is prevented. A nut 63 mounted on the shaft 4 presses the inner race 64 against the inner race 65 of the thrust bearing 66 and holds the said inner race 65 against the flange 67 formed on the shaft 4. The outer race of the bearing 60 is not engaged on the left side as viewed in Figure 4. The outer race of the thrust bearing 66 is held against axial movement between the shoulder 68 formed in the bearing housing 5 and the threaded collar or ring 69 which threads inside the said bearing housing 5. The inner race of 66 is also restrained axially in both directions.

It will now be observed that the shaft 4 is held against radial or axial play, the thrust bearing 66 being designed to resist thrust exerted in a direction toward the left as viewed in Figure 4. Thrust to the right which occurs under certain conditions is carried by the radial bearings 60 only.

The shaft 4 has a cylindrical portion 70 which terminates at the right by a radial shoulder 72 forming a sealing surface. The impellers 2 and 3 are assembled on the outer cylindrical shaft section 73, being keyed to the shaft section 73 preferably by suitable Woodruff keys or the like and held against endwise displacement by a cap screw 74 and a spring lock washer or the like. The hub 26' of the impeller 2 bears endwise against the hub 75 of the impeller 3 and the rear end of the impeller 3 has a radial surface 76 forming a sealing shoulder to cooperate with the sealing rings of the shaft seal 6.

The radial annular sealing ring surfaces 72 and 76 are preferably faced with a wear-resisting metal such as stellite, chromium, or the like. The surface 76 is sealed to the shaft section 70 by pressure and the surface 72 is sealed to the shaft section 70 by being integral therewith. A pair of sealing rings 77 and 78, which may be made of graphite or other wear resisting material or a suitable metal which may also be faced with wear-resisting facings where they engage the corresponding sealing shoulders 76 and 72, are mounted upon the shaft section 70, being assembled thereupon before the impeller 3, with its sealing shoulder 76, is fastened upon the shaft. A pair of flexible elastic diaphragms 79 and 80, preferably made of synthetic rubber resistant to oil and being of tubular corrugated form, are provided with axially extending flanges 82, 83 seated in corresponding counterbores formed in the inner ends of the sealing rings 77 and 78. The innermost ends of the diaphragms 79 and 80 are provided with radially extending flanges 84 and 85, and these flanges lie flat against a central ring 86 to which they are sealed, being clamped thereto by the cooperating surfaces of the sections 88 and 89 of the oil reservoir housing 87. These sections 88 and 89 have at their inner radial portions transverse clamping surfaces for engaging the flanks of the ring member 86, provision being made for receiving the flanges 84 and 85 in the grooves formed in the reservoir sections 88 and 89, although it will be understood that this specific manner of receiving the flanges 84 and 85 is optional. At their outer peripheries the reservoir sections 88 and 89 have cooperating flange portions 90 and 92 clamped together with an interposed gasket 93. The flange 92 of the reservoir section 89 is clamped by means of cap screws 94 against the corresponding planar annular surface 95 to hold the entire shaft seal assembly in place tight with respect to the bearing housing 5 and with respect to the main frame section 19. It will be observed that the cap screws 94 are passed from the outside of the bearing housing 5 into the flanges of the two sections 89 and 88 to clamp the outer peripheries of these sections tight and hold them firmly to and tight with the bearing housing 5. The bearing housing 5 is held by the ring of cap screws 96, likewise releasable from the back side but sealing, by means of a suitable gasket, the bearing housing to the main housing section 19.

The oil reservoir and shaft seal parts are first assembled and fastened together by the cap screws 101 before the assembly is inserted in the pocket formed within the recess or bore 47.

The sealing rings 77 and 78 are thus sealed yieldably and flexibly to the central ring 86 to define a fluid-tight chamber, which may be termed a lubricating chamber, between the said sealing rings 77 and 78.

While the natural resiliency of the rubber or rubber substitute diaphragms 79 and 80 tends to apply the sealing rings 77 and 78 to their cooperating sealing shoulders 76 and 72, I prefer to apply a more positive pressure to make this seal, particularly in view of the fact that in the normal operation of the pump the final stage of the pump is under a definite pressure, even at the hub of the impeller.

A pair of thrust transmitting sleeves 98 and 99 perform the dual function of clamping the axially extending flanges 82 and 83 into the rings 77 and 78 and of applying the yielding pressure of the compression springs 100 to the asid sealing rings 77 and 78. A plurality of these compression springs 100 are disposed in holes formed in the reduced portion 102 of the central ring 86, the pressure of these springs 100 being high enough to secure the desired sealing effect between the sealing shoulders 76 and 72 and the cooperating sealing rings 77 and 78.

The sleeves 98 and 99 are provided with shoulders for engaging the springs 100 and the flanges 82 and 83 of the respective diaphragms 79 and 80, and are grooved between the said shoulders as indicated at 103 to provide clearance for the said flexible diaphragms.

In like manner the oil reservoir sections 88 and 89 adjacent the said diaphragms are suitably provided with annular recesses to provide for freedom of movement of these diaphragms.

The sleeves 98 and 99 are keyed, to prevent rotary motion, by means of pins 104 which are set transversely in the inner periphery of the ring 86. The sealing rings 77 and 78 and their clamping rings 98 and 99 have a certain degree of universal movement due to the flexibility of the diaphragms 79 and 80 and to the freedom of the sleeves 98 and 99 with respect to the keying pins 104. Thus the seal is maintained, even though the shaft be eccentric, or it may have a small amount of end play or wabble, all of which deviations from true circular motion of the rings 76

and 72 may be followed by the sealing rings 77 and 78.

The inside of the reservoir 87 constitutes an annular chamber 105 which communicates with the lubricating chamber under the diaphragms 79 and 80 through an intake duct 106 at the lower end and the discharge duct 107 at the upper end, by virtue of which the rotation of the shaft draws lubricant in through the duct 106 and discharges it through the duct 107. These two passageways 106 and 107 are drilled through the central ring 86, being preferably in line with each other and lying at one side of the center of the shaft section 70, as shown in Figure 5. The shaft rotates in such direction in respect to the openings as to draw liquid from one—the lower—opening and discharge it at the other—top opening. Obviously, so long as one opening provides a trailing edge or opening for the introduction of liquid and the other a leading edge or opening for the discharge of liquid, these two ducts may be disposed in various positions about the periphery of the ring 86.

The annular reservoir space 105 is provided at its bottom with an oil drain passageway 108 which is formed by drilling through the flange of the bearing housing 5 and through the flange 92 of the reservoir housing section 89, and intercommunication with a groove 109 which is cut in the flange 90 to put the said drain passageway 108 into communication with the lowermost part of the oil reservoir chamber 105. A like passageway 110, provided with a filler pipe with a spring-held cover or cap at its upper end is formed at the top of the bearing housing 5 and the oil reservoir 105.

In the assembly of the pump and its shaft seal, the shaft is first located in the bearing housing 5 and the bearing housing 5 is then secured to the main casing section 19. Thereupon the shaft seal assembly 6 is introduced into the recess provided by the cylindrical opening in the main housing section 19 and by the flange of the bearing housing 5. The seal assembly is held in place by the cap screws 94, and a drain plug and filler pipe with a spring-held cover are connected to the drain opening and the filling opening for the reservoir of the seal;—(see Fig. 5). Then the impeller 3 is put in place, its sealing ring 76 bearing against the seal ring 77. Then the casing section 14 is clamped in place, as by means of the bolts holding the flanges 17, 18 together. Thereupon the front impeller 2 is fastened in place by means of the cap screw 74 and then the front section 7 is clamped to the intermediate section 14, as by the bolts passing through the flanges 16, 15. The oil reservoir and its connecting spaces are filled with a charge of suitable fluid lubricant and the operation of the shaft within the lubricating chamber circulates the oil through the inside of the seal. A charge of lubricant is placed within the bearing housing 5 in contact with the thrust and radial bearings 66, 60 and 59, and this oil is in thermal conductive relation to the seal reservoir and to the outside of the seal between the shoulder 72 and the ring 78. It is to be observed that the reservoir section 88 forms a part of the back plate of the impeller 3, so that the oil in the reservoir 105 is in thermal conductive relation to the liquid which is being pumped within the impeller chamber of the impeller 3. Since this is a self-priming unit, the self-priming charge of liquid which is trapped in the pump will always be carried in contact with parts which are in thermal conductive relation to the lubricant of the seal.

The operation of the pump shown in the drawings and above described is as follows: Assuming that a suitable suction hose is connected to the inlet connection 9 and that twin fire hose or the like are connected to the two outlets 55, 55 and that the pump contains a charge of liquid which may have been trapped by a previous operation or which may be poured thereinto through one of the openings 55, the liquid level will stand at a point below the bottom of the inlet opening 9, whereby an adequate priming charge is retained and both stages of the pump thereby are submerged in liquid and form a part of the liquid trapping capacity.

Also assume that the oil reservoir and the lubricating chamber are filled with a suitable lubricant. Depending upon the climatic conditions which may be encountered, the liquid filling may, for cold weather operations, comprise an anti-freeze solution and the lubricant may be an oil which does not freeze or congeal under the conditions of temperature encountered.

Upon starting the rotating system including the shaft and the impellers into rotation, the first effect is the displacement of liquid from the trap and the first stage, through the second stage, into the separator space or chamber 33 and connected parts. Immediately thereupon, the liquid from the separator tends to return through the auxiliary or priming throats 36 and 38, forming a mixture within the impeller chamber of the impeller 3, the mixture being driven out of the throats 35 and 37 into the separator, where the mixture tends to separate into liquid and gas, the gas passing out through one or both of the openings 55.

At this stage it will be observed that the impeller 2 and its casing are quite emptied of liquid and hence run only in air, except for the small return of liquid through the throat 27. This liquid is trapped in the space 28 below the inlet opening 22 of the second stage and cannot be pulled over into the second stage. The first impeller 2 with the admixture of the inflowing liquid is capable of creating a differential of air pressure upon its delivery side thereby assisting the self-priming stage in the work of pulling air out of the trap 8. Since no close fit is required in the form of impeller shown in the first stage or, for that matter, in the second stage, the pump may be run indefinitely on the priming phase without injuring the shaft seal or the first stage or, for that matter, any other stages which may be interposed between the first and the last. It is, of course, contemplated that the present pump may be made up in as many stages as required, by the addition of additional impellers such as 2 and intermediate casing sections such as 14, to accommodate the additional stages.

However, the idle running on the priming phase with merely air passing through the pump cannot injure the pump, even though it may occur for a long time. Likewise, if the pump be required to operate for a considerable period of time in order to raise liquid through a long suction pipe or an unusually high distance, no injury can be done to the pump, as the impellers of the stages (all except the final stage), are running only in air, and the final stage is operating self-priming.

The capacity of the trap 8 and the intermediate stages acts as a displacement piston, creating a suction in the suction pipe by the displacement of the liquid itself, after which the actual

entrainment of liquid and the discharge of the same as mixture into the separator chamber 33 occurs.

It is contemplated within my invention that the system of automatic compensation and automatic hydraulic balance which occurs by virtue of the peripheral reentry of the priming liquid during priming may be accomplished in various forms of casings and impellers in the final stage. Also, it is contemplated that instead of pairs of throats, throats one or more in number having the capacity for discharging mixture and readmitting liquid freed of air may be employed, all without departing from my invention.

While I have shown relatively straight blading on the impeller 3, and so, also, on the impeller 2, in conjunction with a casing the inner periphery of which is swept by the tips of the impeller blades, it is to be understood that for certain purposes a volute type of casing, with a cut-off, integral throat or multiple throats, may be employed for either or both of the impellers 2, 3 and any intermediate impellers. I find that the substantially straight blading in conjunction with the sweeping of the inner periphery of the casing gives a better characteristic for the specific purpose for which the pump is designed in the present disclosure, that is, a high pressure, high delivery fire pump in which it is desired to maintain fairly flat pressure curve over the delivery range. This pump, as herein specifically illustrated and described, will do so in rather surprising degree for the reasons set forth in the description of operation of the pump of my invention covered by application, Serial No. 751,445, filed Nov. 5, 1934, which has matured in Patent No. 2,134,254.

In the operation of priming, liquid will finally be drawn in through the intake trap 8 and will fill the impeller 2 sufficiently to permit it to operate, and thereupon it will exert a wet vacuum, driving any trapped air between the first and the last stages out through the last stage, and the pump then begins to work upon liquid alone. If at any time the suction intake is uncovered, or air is drawn in, the pump may drop to the priming operation automatically, depending upon the amount of air which enters.

By the multi-throat operation of the priming stage, and the fact that the intermediate stages work idly in air during priming and immediately seize the liquid and produce wet vacuum upon pulling over of the liquid, a very rapid evacuation of air from the suction pipe to produce priming, and a very rapid delivery of full working pressure thereafter, is attained by this pump.

It is to be observed that the impeller 2 is provided with the housing 24, 25 in order to facilitate the development of an orderly flow and pressure from the discharge of liquid from the periphery thereof. Theoretically, the housing 24, 25 would not be necessary, in view of the shrouding 26 on the back side of the impeller, and as a matter of fact, if the impeller is semi-shrouded or is a closed type of impeller, a housing at the discharge would not strictly be necessary, but it would be then necessary to have sealing rings for closing off the intake from the discharge pressure. In the construction shown, by having the shrouding 26 and the back plate 24 on the otherwise open impeller 2, delivery pressure exists at both the radial ends of the gap between the shrouding 26 and the back plate 24, so that leakage is reduced to a minimum. Hence, a close fit between the back plate 24 and the shrouding 26 is not strictly necessary.

In the event that the seal between the ring 77, that is, the front ring, and the sealing shoulder 76 should fail, pressure from the pump casing would then escape into the interior of the lubricating chamber between the diaphragms 79 and 80 and the shaft section 70. This would immediately transmit pressure to the reservoir 105 and cause a discharge of liquid out through the filling pipe and spring-held cover, so that the operator would at once be apprized of the failure of the sealing ring. This, however, would not allow escape of pressure into the bearings, since the second seal between the sealing ring 78 and the shoulder 72, which is always running under oil, both inside and outside, would still be in position to separate the discharge of the liquid in the pump from the bearings in the housing 5. Also, the pressure which would then be brought against the diaphragm 80 would tend to hold the ring 78 and the shoulder 72 all the more firmly in engagement and thus prevent escape of liquid into the main bearing.

As heretofore explained, the seal as a unit may be removed by first taking off the casing sections 7, 14 with the impellers 2 and 3, whereupon the seal may be removed as a unit and replaced as such, either by substituting a new unit or by repair of the previous one.

It will be observed that by the form of the semi-shrouded impeller and the back plate open at the center as herein employed, it is necessary to provide only a single shaft seal for both stages, or as many stages as it may be desirable to include in the pump.

By placing the seal on the high pressure side a degree of protection is afforded as above indicated. While the seal may be placed at the low pressure end, it will be observed that, in that event, the seal will not have the protection for the bearings and for giving an indication of trouble which the specific position which I have selected affords.

The displacement effect of the liquid which is trapped has also a beneficial effect in assisting, at least in some degree, when the pump is started with the suction pipe sealed, the return of priming liquid at low vacuums. The type of pump herein disclosed returns priming liquid in increasing amounts as the vacuum increases up to a certain point, and the air handling ability increases with the amount of liquid returned, up to a certain point. The displacement effect when the suction pipe is sealed before starting assists in creating an initial vacuum.

By the use of open impellers the axial extent of overhang is greatly reduced. Also, sealing rings are avoided. By using the semi-shrouded anterior stage or stages, sealing rings or shaft seals between stages are avoided.

The hydraulic balance type of the final stage is peculiarly effective in that the automatic compensation of return priming liquid facilitates as rapid evacuation as possible, and it is quite automatic without loss of efficiency. Where a return passageway from the separator to the intake side is employed there is always danger of a clogged valve, or failure to shut off. Particularly if a manual control were supplied, this would be undesirable, since the equipment is to be handled by inexperienced people and must be operated and serviced by inexpert attendants.

The multiple throat type for the first unit or the anterior units or stages is particularly de-

sirable, in that it reduces the radial load on the shaft which overhangs the bearing. Furthermore, it gives a high delivery rate in a compact construction.

The placing of the self-priming unit as the final stage is advantageous in that maximum displacement of liquid is secured in the initial stage of priming, and there is no loss of liquid, either by leakage or otherwise, as would be the case if the priming unit were in the first or an anterior stage.

A check valve may be used on the suction connection to limit the backflow, or even as a substitute for the trap, but the trap is a more desirable construction, even with a check valve to break the return flow, since leakage or disabling of the check valve in that case does not allow the pump to lose its priming water.

While the semi-shrouded type of impeller for the first stage is desirable in point of compactness, it does introduce end thrust which must be taken up by a suitable bearing. Its chief advantage is the freedom from damage by grit or sand in the water which would be injurious to the sealing rings of a closed impeller. The closed impeller, for the first or anterior stages, takes up more axial room and thus tends to impose a greater overhang on the radial bearings.

The present pump is designed for a capacity of approximately 570 gallons per minute at about 140 ft. head, or 300 gallons per minute at about 350 ft. head, lifting liquid by suction in the neighborhood of 22' feet with a 40 BHP gasoline engine feeding two standard fire hoses and nozzles.

I do not intend to be limited to the details shown and described, since numerous modifications will at once be apparent to those skilled in the art, all of which I intend to come within the spirit of the following claims.

I claim:

1. A self-priming centrifugal pump of two or more centrifugal stages, comprising a pump casing having an inlet trap anterior to the first stage and a separator posterior to the last stage, each stage comprising an impeller having a central inlet and peripheral discharge, the impeller of the last stage comprising an open impeller cooperating during priming with a charge of recirculating priming water which is trapped in the pump casing by the inlet trap when the pump stops and which is driven out of the anterior stages into the final stage to function with the final stage as a liquid seal and as a medium to be mixed with air in the final stage to carry air out of the anterior stages and the inlet trap and liberate the same in said separator the final priming stage comprising an impeller casing with a main and an auxiliary discharge port communicating with the separator, the auxiliary discharge port permitting reentry of priming liquid from the separator to produce air entrainment in the impeller casing and discharge of the resultant mixture out of the main discharge port into the separator, and a delivery connection from the top of the separator, said stages being connected to said delivery connection in series with each other only.

2. A plural stage self-priming centrifugal pump comprising a common casing having a trapped inlet for retaining a priming charge of liquid, a discharge outlet, a separator in advance of the discharge outlet serving to disentrain gas from a mixture of gas and liquid discharged into it, a plurality of centrifugal pump units permanently connected in series only between the inlet and the separator and having a plurality of impellers on a common shaft, each with a central inlet and a peripheral outlet, the impeller of the final unit being an open impeller and being adapted to recirculate liquid during priming from the separator and to form and to discharge into the separator a mixture of said liquid and gas from within the casing to draw liquid into the first impeller, the final unit discharging fluid tangentially during both priming and liquid pumping.

3. The pump according to claim 2, wherein the first impeller is an open impeller with shrouding on its back side, an impeller casing within the common casing, the delivery side of said impeller casing being open about the shaft to the back side of said shrouding and to the inlet of the next impeller.

4. The pump of claim 2, wherein each of said impellers has an impeller casing, each casing comprising a plurality of tangential outlets with a concentric channel portion in advance of each outlet, the blades of said impellers being arranged to sweep the corresponding concentric portions, and means cooperating with the casing of the final stage for recirculating priming liquid from the separator into the periphery of the final impeller to entrain gas with the liquid to be discharged into said separator.

5. The pump of claim 2' wherein the sole communication between the separator and the impeller of the priming unit is peripherally of the said latter impeller.

6. In a plural stage self-priming centrifugal pump, a main casing comprising a front portion including an inlet trap, an intermediate portion and a main frame portion, said main casing enclosing a plurality of impellers mounted on a common shaft for serving a plurality of centrifugal stages, the front portion providing a front plate and central inlet for the impeller of the first unit, the intermediate portion providing an impeller casing and back plate for the impeller of the first stage, said intermediate portion providing for the second stage a front plate with a central inlet communicating with the discharge of the first stage, the main frame portion providing a separator for cooperation with the impeller of the final stage and providing a housing and back plate for said impeller of the final stage, said last named housing having a peripheral connection with the separator, and means for the return of priming water from the separator to the last named impeller to carry air out by entrainment with the water during priming.

7. A plural stage self-priming centrifugal pump comprising a common housing having an inlet trap in advance of the first stage and a separator cooperating with the final stage to constitute the final stage only a self-priming unit, all of the stages being connected permanently in series only and serving in connectiton with the intake trap to retain a body of trapped liquid which operates as a gas entraining and evacuating medium in the final centrifugal unit during self-priming, and a common rotating system consisting of a plurality of impellers and a common shaft, all of the stages in advance of the final stage emptying themselves of liquid to initiate the self-priming action of the final unit, said housing providing a central inlet and a peripheral outlet for each of said impellers.

8. The pump of claim 7 wherein each stage is a straight centrifugal unit having a central inlet and peripheral discharge and fluid pumping

being produced by travel of the fluid radially outward from the center.

9. In a self-priming pump, a casing comprising an impeller chamber, an impeller therein, said casing comprising a separator extending above said impeller chamber, said chamber having a plurality of pairs of throats and a pair of manifolds open at both ends into the separator, each manifold communicating with the corresponding throat of each pair of throats.

10. A self-priming centrifugal two stage fire pump having a horizontal shaft and comprising a main casing which provides an intake trap in advance of the first stage, a discharge trap serving as a separator posterior to the second stage, said shaft carrying two impellers, said casing further providing a housing for the impeller of the first stage, said housing comprising a plurality of discharge passageways and concentric portions swept by the first stage impeller in advance of each discharge passageway, said casing providing also a housing for the impeller of the second stage, said second housing having a plurality of juxtaposed pairs of discharge passageways and concentric portions swept by the second stage impeller in advance of each pair of discharge passageways, the plurality of passageways of the first stage emptying into an annular space which communicates with the intake of the second stage housing only and the plurality of pairs of discharge passageways of the second stage housing opening into the separator whereby the pump is self-priming by the entrainment and discharge of air in said second stage and whereby the pump provides a substantially uniform high pressure over a wide range of deliveries of liquid, said separator having an open outlet to which the first stage is connected only in series with the second stage.

11. A self-priming centrifugal two stage fire pump comprising in combination a pump body and a pair of open impellers on a common driving shaft, said body including a concentric casing with a central inlet and a plurality of peripheral discharge throats cooperating with the first impeller, said body including a concentric casing with a central inlet and a plurality of pairs of throats of which the anterior throat of each pair comprises a main throat through which liquid is always discharged outwardly, and of which the posterior throat of each pair comprises a priming throat through which liquid moves inwardly to produce gas entrainment during priming and outwardly during liquid pumping to discharge liquid, said second concentric casing cooperating with the second impeller, said body comprising an inlet trap the lower end of which opens into the central inlet of the first casing and the upper end of which has a suction inlet, said body comprising a separator chamber surrounding the second casing and having an enlargement above the second casing to provide gas separating space for the entrained gas, there being a discharge connection from the upper end of the separating space, said body having walls providing an annular space between the first and second casing and communicating at its outer periphery with the peripheral discharge throats of the first casing and at its central part communicating with the central inlet of the second casing to conduct the fluid discharged by the first impeller into the inlet of the second impeller.

12. The combination of claim 11 wherein the first impeller has a shrouding on its side facing toward the second impeller and the first casing has a wall adjacent said shrouding which wall is open at the central part and out of rubbing contact with the rotating parts of the pump, said opening being substantially closed by said shrouding.

13. A two-stage self-priming centrifugal pump requiring no valves, comprising the combination of two centrifugal pump units connected permanently in series only to a discharge connection, each unit comprising an impeller chamber with a central inlet and peripheral discharge throating and an impeller; a common impeller shaft, the first unit being anterior to the second and having an inlet trap connected to its inlet and being non-priming, the second unit having a separotor communicating with its discharge throating and being self-priming by virtue of the throating of the second unit comprising an opening permitting reentry of liquid from the separator when the pump draws air and discharge of liquid when liquid fills the pump, said inlet trap and separator cooperating with said units to trap a charge of priming liquid.

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