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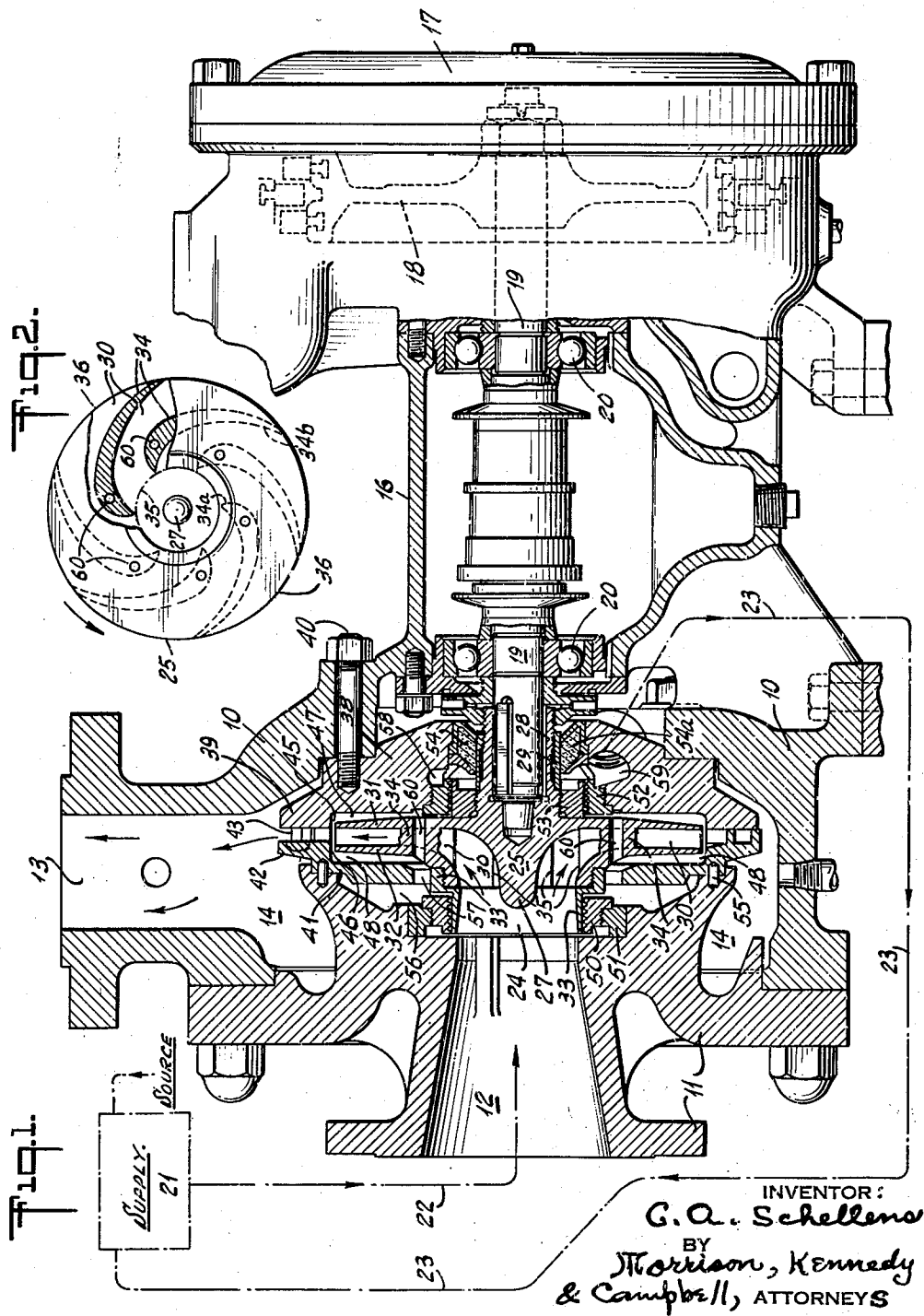
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2,700,344

CENTRIFUGAL HYDRAULIC PUMP

Filed July 29, 1950

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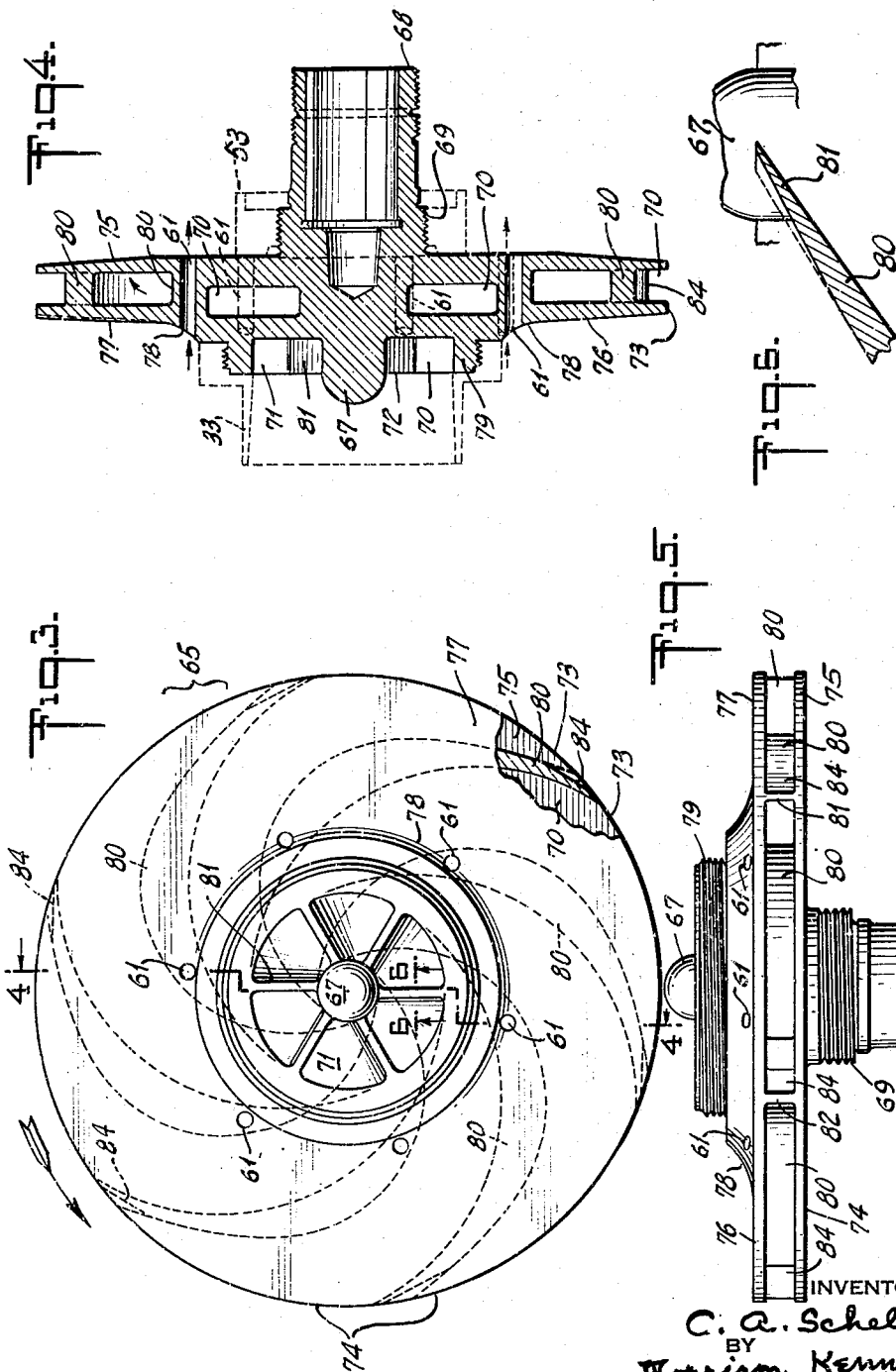
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3 Sheets-Sheet 2



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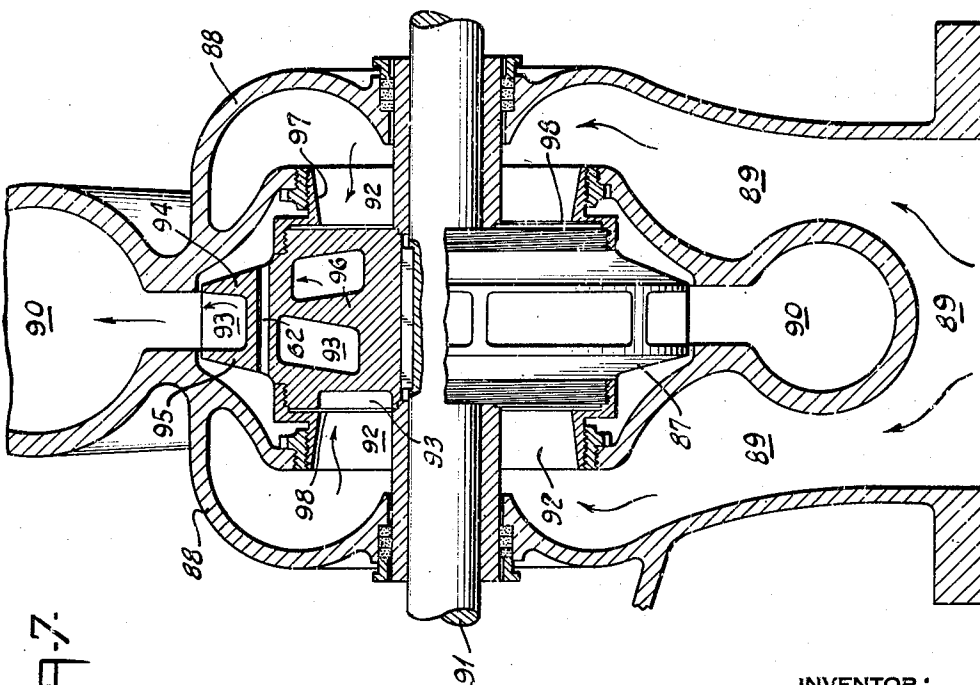
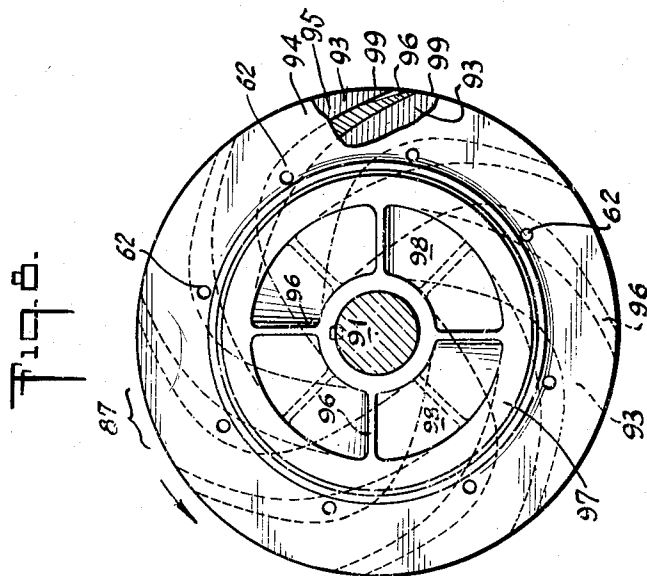
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CENTRIFUGAL HYDRAULIC PUMP

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3 Sheets-Sheet 3



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CENTRIFUGAL HYDRAULIC PUMP

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Application July 29, 1950, Serial No. 176,599

2 Claims. (Cl. 103—112)

This invention is a novel centrifugal hydraulic pump of the general class wherein a shaft-borne impeller or runner is power-rotated, as by a turbine, within a closed casing wherein the impeller receives, as through an inlet conduit, the water or other liquid to flow through the inlet to the impeller eye or entrance space surrounding the axis of rotation. The liquid by a circular series of impeller mouths enters the centrifugal flow passages and, by the forcing action of the impeller rotation, flows outwardly for eventual discharge, by way of peripheral outlets leading to a delivery conduit for use or disposal.

This invention pertains especially to that well known type of pumps wherein the enclosed impellers are laterally closed, having uninterrupted sides or bounding walls extending between the impeller inlet openings and the outward discharge openings, and rotating with the impeller, without contact between casing and impeller. In such types the impeller outward flow passages, usually of approximately oblong section, are entirely internal, constituting channels which usually extend from a central axial path near the inlets with gradual change of direction of smooth curvature for outward flow and final delivery in planes extending at right angles to the general or rotary axis of the pump. The present invention pertains to the laterally-closed impeller type of rotary impeller.

An underlying problem to which the present invention is directed relates to the very common existence of factors causing serious differential pressures upon the closed opposite sides of a high speed pump impeller, the differences between which pressures tend to the creation of a very substantial resultant axial pressure, in one direction or the other, upon the impeller and pump shaft. Various factors are responsible for these inequalities of liquid pressure and thrust, and in all cases there is a strong tendency to harmful mechanical results in respect to the shaft bearings, especially the thrust bearings thereof which, under varying or constant substantial endwise thrust become impaired by wear and suffer increased cost of maintenance, to a highly objectionable extent.

The drawings

Fig. 1 is an axial or longitudinal radial section, partly in elevation at the driving end, of an illustrative centrifugal hydraulic pump of the conventional single-eye or one-inlet type, as a first form, embodying the present invention; and the figure for convenience may be considered a vertical section, in cases wherein the pump is installed to discharge upwardly, which is not a necessary limitation.

Fig. 2 is a left end elevation showing in face view the impeller of Fig. 1, detached from other parts of the pump, and partly cut away to show the interior passage and blade structure.

Showing a second form, in Figs. 3 to 6; Fig. 3 is a left end elevation of a modified and improved impeller which is particularly adapted to full utilization of the benefits of the invention and overcomes certain limitations which are encountered in the application of the invention to the impeller shown in Figs. 1 and 2; the Fig. 3 impeller being shown detached from the pump, looking into the single inlet or eye thereof, and broken away to show certain interior construction; the impeller of Figs. 3-6 being adapted to use in various types of hydraulic pump including that of Fig. 1; the illustrated impeller resembling in general principles that shown in

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applicant's expired prior Patent No. 1,664,488 of 1928, but supplemented by the novel features of the present invention.

Fig. 4 is a transverse vertical sectional view of the impeller of Fig. 3 taken on the section line 4-4 of Fig. 3; Fig. 4 like Figs. 3 and 5 affording a true rather than a mere conventional showing of the flow passages, the enclosing side walls and the interior metal portions or partitions which define such passages.

Fig. 5 is an underneath or inverted plan view of the impeller of Figs. 3 and 4.

Fig. 6 is a detached view of a structural detail, taken in section on the section line 6-6 of Fig. 3.

Fig. 7 is a central vertical section of a two-inlet or double-eye pump, having passages of the same general form as in the impeller of Fig. 3, and following in general the pump of that type illustrated in the prior patent of this applicant, No. 2,101,653 of 1937, but reconstructed and modified to embody the principles of the present invention.

Fig. 8 is an end elevation or righthand face view of the impeller per se illustrated sectionally in Fig. 7.

First form, Figs. 1 and 2

Describing first the conventional portions (considered without the present improvement) of the hydraulic pump shown in Figs. 1 and 2, at the front end of the system, being the left end of Fig. 1, is the pump casing 10, 11, consisting of a fixed casing part or body 10 and the complementary front head or cover part 11 bolted on.

The casing head 11 is formed with an inlet conduit 12 delivering axially into the entry spaces of the impeller. The casing body is similarly formed with a conduit 13, providing the final outlet delivering from the pump discharge chamber 14 for any desired use or destination. While referring to the casing parts it is here explained that the body 10 is provided with a closed intermediate extension 16, while at the rear or righthand end of the apparatus, is a closed rear casing 17, connected with casing 16 and containing a suitable driving motor, such as the indicated turbine motor 18. A central shaft 19 is turned by the motor and is unitary with or coupled to the shaft which carries the impeller or runner element 25 to be described. This shaft 19 operates in ball or roller bearings 20, 20 which, taken separately or in cooperation may serve also as thrust bearings, intended to resist axial or endwise shiftings, and being vulnerable to excessive thrust action.

The water or other liquid is brought to the pump conduit 12 by any desired exterior conduits or pipes, leading from a source of hydraulic head or liquid supply providing the necessary initial pressure, which may be low or high. There is diagrammatically indicated a supply 21, fed from any available source, and delivering through piping 22 into the inlet conduit. As a preferred auxiliary detail a pipe 23 is shown leading from one of the pump leak chambers 59, to be described, around to where the escaping liquid is delivered freely into the relatively low-pressure inlet 12, either directly or by way of supply 21.

The illustrated pump, according to conventional practice, has an entrance space 24 called the "eye" of the pump, being that completely circular portion of volume or space through which the flow passes from the conduit 12 into the impeller 25. The impeller is a preferably one-piece rotary member driven at high speed from the shaft 19. One customary part of such an impeller is a central and frontwardly extending portion, designated a crown, projecting into the eye-space 24 and thereby assisting to define the annular flow from the inlet into the impeller flow passages 30, to be described. The crown is shaped with a rounded nose followed by smooth out-curves toward the spaces and enclosing walls of the impeller; the crown in this way causing an outswinging flow of the entering liquid, minimizing obstruction and turbulence, the liquid passing therefrom through the impeller mouths, in this case six of them, and along the flow passages. The mounting of the impeller, thus partially described, is, in this instance, effected by means of a rearward extension or hub tube 28 of the impeller, this

tube being threaded for securing purposes and keyed to the shaft 19.

The set of six flow passages 30 of the impeller receives and delivers the main flow of liquid through the impeller, from the receiving central portions to the outward discharging portions, and the passages are disposed spirally therebetween to receive efficient centrifugal pressure and velocity toward and beyond the discharge. The flow within the operating part of the impeller is from the eye 24 or the circularly aligned six mouths 35 therebeyond, along the spiral paths to the peripheral discharge outlets 36; and these flow passages are bounded and defined, in their axial dimensions, by the rear and front outer impeller face parts or walls 31 and 32, and transversely by the disposition of the interior metal portions or separators 34 between those walls, for example, in the form of blades as shown in Fig. 2. Between 24 and 35 the flow surrounds the crown.

The impeller rear wall 31 and the similar opposite front wall 32 are closed annular walls between which the outflow occurs. The rear wall 31 and its inside face extend inwards substantially in a plane transverse to the axis, continued thus until the face takes a curve frontwardly as it merges into the curvature of the crown 27. Analogously the opposing front wall 32 extends within a transverse plane in a direction toward the axis, as about 90° thereto, its portions approaching the axis taking a frontward curvature terminating in a substantially axial direction. As clearly shown in Fig. 1, the general disposition of the impeller front and back walls is such that each passage between them tapers progressively from the inlet eye 24 and thence through the mouths 35 into the radially or spirally outward extension of the passage. Where the metal of the impeller front wall 32 is shaped with a curve terminating frontwardly there is preferably employed a conventional impeller extension 33, attached or screw-threaded to the front wall 32 and itself being extending frontwardly in line with the termination of the front wall, thus affording a renewable eye-sleeve adapted to be replaced when impaired.

Between the unitary rear and front impeller walls 31 and 32 are arranged the interior metal portions, in this case shaped of blade form, which serve to separate from each other the outwardly trending flow passages 30. These interior metal parts, between the closing walls, may take various shapes and may be considered as impeller portions which define, in one dimension, the sectional shapes, usually oblong, and progressing contours, of the separate flow passages; each such passage commencing at the mouth line 35, whereat the otherwise annular flow is divided into six streams by the interior portions or spiral blades, and continuing to the impeller peripheral discharge points 36. Further features and details of the impeller itself will be hereinafter further described and explained. Each blade begins at its nose 34^a and ends at its tail 34^b.

Referring to some of the adjacent and associated elements, Fig. 1 shows within the casing, between its rear wall and the impeller, a conventional diaphragm 38 or removable annular supporting member, shaped at its front or inner side to clear the rotating impeller where these parts face each other; and this diaphragm 38 is formed with an upward extension 39 reaching beyond the exit line 36 at the extreme periphery of the impeller. Similarly there is a front fixed annular diaphragm 41 mounted on the casing cover 11 and shaped to face the front side of the impeller, without contact; with an outward extension 42 reaching beyond the impeller discharge exits. The two diaphragms have their upper extensions facing each other and spaced somewhat apart to leave an outward flow space therebetween through which the impeller discharges, in a conventional way, these extensions further acting as supports for a system of cross walls or guides 43 known as diffusers, in the nature of fixed vanes controlling the onflow of the discharge liquid issuing from the impeller.

Throughout the structure it is an aim to minimize metal contact between relatively movable parts. Accordingly the extreme peripheral impeller portions are out of running contact with the diaphragm and extensions, the latter indeed being spaced beyond the impeller rim thus leaving an appreciable free clearance or flow gap 45. At the front side of the impeller there is a similar but not necessarily equal clearance gap 46 between the front wall 32 and the diaphragm extension 42.

This arrangement permits constant and substantially unrestrained backflow of pressure liquid, through these clearance gaps or gates 45 and 46, which are of ample size to obviate appreciable drop of pressure there-through, and, in this instance, into relatively wider clearance spaces 47 and 48 constituting chambers existing by reason of the design of the diaphragms where they face the impeller rear and front walls. Liquid escaping from the discharge by the clearances 45 and 46 enter the chambers 47 and 48, flowing toward the axis, under the high pressure, for eventual restriction and release, as by control rings. Other backflows or leakings, if any, at both sides of the impeller, may be similarly controlled.

To prevent undue back leakage and escape of high pressure liquid from the discharge chamber 14 a system of control devices, acting as wearing rings, is conventionally provided in this class of hydraulic pump. Thus, a first or front wearing ring 50 is shown, mounted in a fixed position on the casing head 11, and adjacent to but slightly out of contact with the rotary eye-sleeve 33. This pair of annular elements 50, 33 constitute a couple for control purposes, the fixed one being deemed the wearing ring. As the sleeve is a renewable extension of the impeller front wall the object is attained of minimizing backflow through the several spaces afront the impeller which directly or indirectly receive from the discharge chamber 14. The wearing ring 50 seats fixedly against an annular block 51, both located within a recess in the casing head. The ring and sleeve cooperate by means of a labyrinth structure, in this case provided on the ring, as shown in Fig. 1. This arrangement, hereinabove described, is known as a hard rather than a soft packing. Water escaping the labyrinth ring 50 passes into the lower pressure of the pump inlet.

Just as the eye sleeve 33 serves as a front extension of the impeller for wearing ring purposes, so also the back extension, block or hub sleeve 53 serves as an impeller extension for the same purposes. There is shown first the fixed or labyrinth ring 52 mounted in a seat in the fixed diaphragm 38, this ring being just out of contact with the annular hub sleeve or block 53 rotating with and being a rigid part of the impeller by its seating in a recess of the impeller. Leakage occurs through and beyond this wearing point, where there is provided a supplemental or soft packing ring 54 occupying a three-walled chamber 54^a which extends from the diaphragm 38 inwardly to the exterior surface of the impeller hub extension 28, or rather to a smooth sleeve 29 threaded upon 23, and turning within the packing. The function of the soft ring is to seal the shaft at this point against leakage. The aforesaid hard wearing rings 50 and 52, when the pump pressure is not extremely high, and where there is consequently no appreciable unbalanced axial thrust due to pressures acting on surfaces diametrically within the wearing rings, may be both of the same diameter, as shown, but I may prefer under other conditions to employ slight differences in the wearing ring diameters.

The two sleeves 33 and 53, at front and back, being equal in diameter it will be readily seen that (provided the water supply at the inlet 12 is of a pressure substantially or slightly above atmosphere, and provided the turbine exhausts at a pressure substantially equal to or slightly above atmosphere), there exists no unbalanced axial force due to pressures inwards of the wearing rings, that is, of the clearances thereof, at the two sides. Under other circumstances other well known means would be provided for balancing the thrust due to pressures in these regions, but these regions and these means form no part of this invention and will not be described further.

Further reference is here made to the clearance or back-flow spaces and chambers, and their operation, commencing with the already mentioned chambers 47 and 48 bounded respectively by the impeller closing walls 31 and 32; with which should be mentioned again the gaps or escape gates, channels or spaces 45 and 46 by which the discharged liquid, under high pressure, may pass into the chambers 47 and 48; the portions of which liquid that are nearest to the impeller periphery may exist in a substantially balanced condition owing to the short free communications from the discharge chamber 14 through both of the gaps 45 and 46 into the chambers 47 and 48. Each of these chambers is outwardly bound-

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ed by one of the diaphragms 38 or 41 the latter of which is held in place by a connecting joint 55. Frontward of the diaphragm is another space 56 existing between the diaphragm 41 and the extension of the casing head 11, but this contains only dead liquid. The described escape chambers 47 and 48 are constantly full of liquid and under constant receipt of liquid passing from the high pressure point for flow inward toward the general axis of the pump.

Between the chambers 48 and 56 stands the diaphragm 41, extending radially toward the center for substantially the same extent as the impeller walls 31 and 32 but in a way to leave an intercommunication 57, on the way to the wear ring 50. This local system of escape flow clearances or chambers extends to and terminates at the wear ring clearance which forms the leak-restraining element separating the discharge spaces from the entrance spaces of the impeller. This action releases in negligible quantities the escaping liquid into the general inlet 12, for recirculation.

Thus the escape chambers to the front of the impeller deliver their leakages back into the general inlet; and the same principles are provided in respect to the impeller and associated parts extending rearwardly. Thus the rear clearance chamber 47, receiving directly from the discharge chamber 14, extends adjacently alongside the impeller rear wall 31, and inwards thereof extends further toward the axis to reach the labyrinth packing between the rear ring 52 and the annular wear ring sleeve 53 turning with the impeller. Thus all leakage to the rear of the impeller hub traverses the wear space between 52 and 53, this small proportion of liquid passing thence into a system of annular chambers 58 inside of the rear diaphragm 38, from which it issues into a final enlargement 59 of chamber 58, from which the liquid may be allowed to release freely into the pipe 23, already mentioned, which conducts this small quantity of escape liquid back directly or indirectly to the inlet conduit 12 of the pump.

The present improvement will next be explained, on the basis of the example shown in Figs. 1 and 2.

To disclose specifically this improvement, it involves the modifying of the impeller by forming therein the series of cross-ducts 60, each extending from one side to the other, the same being extended internally between the impeller closing walls but issuing at the opposite sides from such walls. These cross-ducts 60 are wholly isolated from the flow passages 30 but constitute communications between the clearance channels and chambers which receive the leakage liquids passing back to the front and rear of the impeller. Within the impeller, between its side walls, the cross ducts are preferably extended through the interior metal which provides at the same time the blades or other partitions, defining the flow passages. Each of the ducts might be afforded by means of a metal tube inserted and extended through the impeller, issuing at the back and front closed sides; and the interior tubes could be arranged partly or wholly in immersion within the flow passages.

If the ducts be too near to the general axis, that is, inwards of the wearing rings, they will not perform the functions characteristic of the present invention; and they will have no utility if placed too near the impeller periphery, at which point the leakage liquid, received at the two sides direct from the discharge chamber is already reasonably balanced.

For the purposes of the invention therefore the construction may be set forth as follows: the group or set of cross-ducts is to be located within an annular region or zone, between larger and smaller zone circles or boundaries, the larger being well inwards of the peripheral outlets, and the smaller circle being somewhat outwards of the clearance or restriction lines of the wearing rings, e. g. the lines of the labyrinths or of the clearance of the largest wearing rings, at the two sides. The cross-ducts 60 are in an intermediate position located in that zone at a point which is considerably nearer, radially speaking, to the wearing ring than to the impeller outlet. In other words, the duct series should be somewhat outward of the ring but preferably as close thereto as feasible.

The series of cross-ducts should present in the aggregate an ample cross section or area, sufficient to afford free and rapid liquid intercommunication and transfer between the opposite, or front and back, clearance spaces,

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thus to insure practically instant response to any tendencies arising to cause differential pressures upon the projected areas of the opposite sides of the impeller. If there is a constant tendency for excess hydraulic pressure at the impeller front side, the equalizing flow through the ducts 60 may be steadily to the rear, and vice versa; or the flow may be oscillating, frontwardly and backwardly, irregularly or periodically.

The ducts are preferably straight but can be otherwise; and they may be round ducts or otherwise. They may pass through the impeller interior partitioning metal, as shown, or through small tube lengths inserted to traverse such metal and/or the flow passages. The ducts may be in a single series of spaced positions or may be in pairs or multiples. Wherever more free communication is desirable the ducts may be enlarged, with thickening of the interior metal portions to accommodate them. No differential in the frontward and rearward liquid pressures axially upon the impeller can exist more than momentarily.

With a conventional pump and impeller the partition walls, which may constitute blades, may have blunt nose edges at the entrance mouth line, as shown; but in special cases, as where very hot water, approaching its boiling point, is to be pumped, and especially where substantial hydraulic suction exists at the inlet, the partition metal may not be constructed with very blunt entrance edges or blades, such as in Fig. 2 shown, for ebullition then tends to occur, with cavitation and a breakdown of pumping action. The second form hereinafter described illustrates a special structure of a "hot water" rather than a "cold-water" pump. In ordinary cases, with no high suction or temperature the conventional type of impeller is satisfactory. In either type the equalizing means of this invention is of substantial utility.

Second form, Figs. 3 to 6

This form, provided with cross-ducts 61 on the principles described, is of value both for pumping water under the favorable conditions specified for Form 1 and for cases wherein the temperature and/or suction are high enough to cause the described difficulties with Form 1, due to foaming behind the blunt noses of the blades near the impeller entrance mouths. The impeller of Form 2 in its interior structure is wholly different from Form 1, and while each has partitioning metal defining passages, Form 2 eliminates definite blades whose blunt entrance edges would generate cavitation with hot liquid and substantial suction.

In the second form the separation of the flow into streams starts further back and near to the main inlet, so that each passage begins near the eye with helical-axial flow, the mouth-separating metal here being thin and sharp, cutting the flow into the six separate helical passages without incurring the difficulties of Form 1; the flow direction then smoothly swinging outward and entering the general impeller outflow in the form of six separate and substantially spiral passages, until reaching the common exit line 74. This manner of construction is in principle substantially like that disclosed in the aforesaid prior Patent No. 1,664,488, Fig. 2 of which may be compared with Fig. 4 herein. The cavitation defect is avoided by the employment of the helical-to-spiral path and flow through each of the several passages together with the smooth-cutting of the sharp character of the mouth edges.

There are in Form 2 no individual blades in the sense of Form 1; but the interior metal portions between the impeller sides (considered as thin surface metal layers serving as closing walls) are formed as partitions specially shaped solely to provide the described axially progressing and then outtrending passages; and the only parts comparable to blades being the thinning parts of the separating metal to afford sharp or knife edges at the intakes and discharges. In Form 2 the interior metal parts at the entrance mouth line 72 should have their passage-defining faces at a small mutual angle where they intersect at the eye as indicated in Fig. 6; and yet, further along, the partitions between passages must be of substantial thickness, to accommodate the balancing cross-ducts 61. These conditions being practical, as shown in Figs. 3-6, this type of structure is particularly suitable for pumping operations wherein, within the important zone defined, the tendency to unbalance of pressures on the impeller front and back sides is neutralized by the

balancing effect of the cross-flow through the ducts 61 between the front and back outer sides of the impeller.

Referring to the details of Figs. 3 to 6, the cross-duct feature 61 is embodied in the impeller 65, shown per se; it being understood that the impeller is to be operated within a casing and associated with other parts, for example of the character illustrated in Fig. 1. Thus, it is to be understood that the cross-ducts 61 lead to and from clearance spaces existing between the impeller closed sides and the respective adjacent diaphragms on the principles of those designated 38 and 41 in Fig. 1. For explanatory purposes it may be said the pump in which the impeller 65 is used may have wearing and packing rings like 50 and 52 and accompanying parts; and other features also may be in common.

The flow passages 70 of the second form are essentially different from those of the first form, resulting in different operations and results; each passage starting in the form of an axial helix, this helical form progressively changing to a spiral form of passage trending outwardly for discharge at the periphery. The entrances or mouths 71 of the several passages extend from a mouth line or plane 72, from which the continued flow takes place. After traversing the passage entrances and the main parts of the passages the flow streams reach and take exit by the peripheral exits 73 arranged in a discharge line 74. Fig. 4 indicates a few of the sections of successive flow passage, which show the oblong forms, with corresponding sides shown parallel and perpendicular respectively to the impeller axis.

For the accommodation of a series of such flow passages the impeller is of a structure described as follows. The impeller has the closed rear surface or wall 75 and opposite to it the closed front surface 77. The wall 75 has a curve 76 merging into the crown; and wall 77 a curve frontward toward the threaded boss 79, which may carry an eye-sleeve. The impeller hub has a tubular back extension 68 by which the impeller is keyed to the shaft; also a threaded boss 69 to receive the sleeve block or collar 53 of Fig. 1. Similarly at the front is a boss 79 adapted to receive the eye-sleeve 33 of Fig. 1.

The passages 70 may be defined as being of substantially quadrilateral section, Figs. 4 and 5, two of the walls of which are surfaces which are substantially helicoidal, the other two being surfaces which are substantially spiral, throughout their length; the spiral surfaces extending from the outer periphery of the impeller inwardly with a decreasing pitch terminating at or near the eye, Fig. 3, or the mouth line 72, where said pitch becomes zero; and the helicoidal surfaces extending from the eye to the discharge with a decreasing pitch becoming zero at or near the peripheral discharge line 74. Apart from the shape of the impeller and interior passages, the adjacent elements of the impeller including wearing rings and associated parts, may be as shown in the first form, Figs. 1 and 2, and no further description of these general elements is deemed necessary. The improved impeller confers on the pump a smooth, continuous flow action after a similar entrance.

The impeller, although preferably a unitary piece of metal, may be considered as composed generally of its closing walls 74 and 76 and interior thereof other metal portions or partitions 80, which are not of the character of blades except in a broad sense, but which are configured to define the passages and produce the helical-spiral manner of flow through the impeller. These interior metal partition members are not simple to describe as such, but may best be referred to as constituting and occupying the entire interior of the impeller body other than the spaces which constitute the six helical-spiral flow passages. One definite interior partition part may be referred to as involving the sharp entrance edges 81, as seen in Figs. 3 and 6. As shown in Fig. 6, this entrance 81 portion of the interior metal is machined away and sharpened, and as well is placed at an acute entrance angle to effect the smooth cutting of the water as it enters and takes up its helical whirl within its passage. The curved dash lines 83 represent the boundaries of the respective flow passages, and as well of the separating metal portions between such passages, Fig. 3 indicating these dash lines and as well the successive passages 70 and the separating metal 80 therebetween. This description makes clear how ample interior metal is available for the introduction of the cross-ducts, as by drilling, without in any way disturbing the sharp character of

the entering edges of the separating partitions at the impeller eye. It is also made clear how there is sufficient longitudinal extent of interior metal between the balancing holes 61 and the discharge end of each separating portion 84 between two adjacent passages, to present a sharp thin edge for the departing liquid, whereby eddying is avoided.

Since the addition of cross-ducts requires ample thickness at a radial distance which, in the first or cold-water form, requires the ducts to be near the entrance edge, it may be impossible there to locate the ducts at a radius small enough to function as ducts without greatly blunting the blade entrance edges as in Fig. 2 shown, thus sacrificing the advantages of the hot water use of the second form, attained by the changed construction thereof including the sharp entrance angle of the partitioning metal in the axial-helical portion of the flow.

Third form, Figs. 7 and 8

The third form, representative of yet other forms presenting similar problems, is based on the twin-inlet or double-eye type of Patent No. 2,101,653, modified to afford the advantages of the present invention. It also has general features in common with forms 1 and 2; and specifically the three forms constitute practical embodiments of the invention. Detailed description is deemed unnecessary as said patent may be referred to, along with forms 1 and 2, by way of supplement to the disclosures of this chapter.

While symmetrically duplicated as compared with form 2, the flow passages of form 3 are definable in the manner above stated for form 2, and the advantages conferred are comparable, each form presents the provision of thick interior passage-defining metal, very practically adapted for the forming or drilling of the equalizing cross-ducts 62, at the same time allowing the desirable sharpness of the metal edges or blade-like entrances, so important at the inlet to obviate the stated inferiority of structure and operation of the conventional bladed impeller of the first form of the invention.

The third or double-eye form has a circular series of eight spaced apart cross-ducts 62 serving to afford rapid equalization of liquid pressures at the two sides of the impeller 87.

The pump of this modification has an upright casing 88, the under part of which encloses an inlet conduit 89, this being branched to supply the liquid in an axial direction to both the lefthand and righthand sides of the impeller. This liquid after traversing the impeller passes into an annular discharge chamber 90.

The pump impeller is carried on a through shaft 91 by which it is driven. It has symmetrical annular eyes 92, each leading toward the impeller flow passages 93; which are defined by the closed outer layers or walls 94 and 95 at right and left and the specially configured interior metal 96.

The two annular eyes 92 are associated with eye-sleeves 97 mounted on the impeller, and these precede the actual entrance mouths 98. After traversing the eye at each side, and the mouths leading to the helical-spiral flow passages 93 the discharges occur by way of openings 99, of which, at the periphery there may be four and four or eight in peripheral line, delivering to the discharge chamber 90. The spiral portions of the two sets of passages commence well apart within the impeller but trend toward each other as shown in Fig. 7, the separate streams finally issuing peripherally through eight exits distributed in closely spaced alternating arrangement around the central part of the impeller periphery and delivering into the discharge chamber 114.

It is deemed unnecessary to detail the remaining structure of the pump and impeller, as the patent cited may be referred to, except as to the equalizing feature. Thus the diaphragms, the flow clearances and the wearing rings etc. have been sufficiently described. The usual mode of construction is to provide eight cores, four of them representing the four identical lefthand flow passages and the other four the righthand flow passages; these cores being assembled in the casting mold in a manner corresponding with the desired arrangement of the passages. This will be understood by reference to Forms 1 and 2 and to said Patent No. 2,101,653.

However, attention is called that, corresponding with Forms 1 and 2, the cross-ducts 62 here are arranged in a series of eight or more, with all of the ducts in a zone

which is somewhat outward of the wearing or packing rings, and somewhat inward of the final peripheral discharge exits of the impeller; and, as shown in Fig. 8 these cross-ducts are arranged also to penetrate through the overall thickness of the impeller, from one outer side to the other, at points which extend wholly through the interior metal portions or partitions 134, so that while each of the ducts extends through from wall to wall none of them make communication with the flow passages 130.

There have thus been described illustrative embodiments of the present invention for centrifugal hydraulic pumps and the impeller elements thereof, embodying the principles and attaining the objects of the present invention; but since many matters of structure, combination, arrangement, detail and method of operation may be modified within the essence of the invention, it is not intended to limit the invention to such matters except to the extent set forth in the appended claims.

What is claimed is:

1. In a centrifugal pump having casing means and adapted for pumping a liquid at near its boiling temperature, an impeller formed with a central inlet eye at one side thereof and having laterally closed flow passages of substantially oblong or rectangular cross section communicating with said eye and discharging at the periphery of said impeller, each of said passages having two axially and radially outwardly extending helical side walls having a generally decreasing helical pitch from their entrance to their discharge ends whereat said pitch becomes zero and whereat each of said side walls merges to one of two surfaces of revolution common to all the said passages, and each of said passages having a radially inner and a radially outer spiral wall of generally increasing spiral pitch from their entrance to their discharge ends, said spiral pitch being zero at said entrance ends whereat said spiral walls form exterior and interior cylindrical surfaces of an impeller eye common to all said flow passages, said flow passages being further characterized by overlapping each other at and near their entrance ends when viewed from an axial direction, and overlapping each other at and near their discharge ends when viewed from a radial direction, the axial overlap ceasing at an intermediate point, and a plurality of axially directed cross ducts extending through said impeller from side to side for equalizing the liquid pressures on the opposite sides of the impeller, each of said ducts being disposed in the material forming the spiral walls of the duct at a location closely adjacent to but radially outwardly of the point at which the axial overlap ceases, said cross ducts being free from direct communication with the interior of the flow passages, and said impeller having a substantial thickness of material between all adjacent flow passages at the point at which the axial overlap ceases whereby the cross ducts are of sufficient size and are located at a sufficiently reduced radius with respect to that of the periphery of the impeller to provide for free flow of fluid through said cross ducts, for effective pressure equalization at opposite sides of the impeller, while the material between adjacent helical side walls of the flow passages provide thin helical entrance blades such as are required for the pumping of a liquid near to its boiling point between adjacent passages at their entrance.

2. A centrifugal pump of the class described including casing means having an axial inlet connected with a source of fluid supply and a peripheral outlet, an impeller with two side walls enclosed therewithin and providing a series of laterally enclosed passages of substantially rec-

tangular cross section with central inlets adjacent the impeller axis and peripheral outlets at the impeller periphery with two helical walls having a generally decreasing helical pitch from their entrance to their discharge ends whereat said pitch becomes zero and whereat each said side wall merges to one of two surfaces of revolution common to all the said passages, and with two spiral walls of generally increasing spiral pitch from their entrance to their discharge ends, said spiral pitch being zero at said entrance ends whereat said spiral walls form exterior and interior cylindrical surfaces of an impeller eye common to all said flow passages, the passage-separating material being disposed at the passage mouths to present sharp and thin entrance edges to the inflowing liquid, the said casing means having a peripherally disposed central outlet chamber surrounding the said impeller outlets and in fluid communication therewith, and said casing means having interior side walls forming together with the impeller side walls backflow side chambers connected to receive free flowing pressure liquid from said peripherally disposed central chamber and direct said flow toward the axis for eventual release, a wearing ring of equal inner diameter on each side of the impeller carried by the casing means, rings of equal outer diameter provided on opposite sides of said impeller, said wearing rings having close running clearance with said impeller rings and cooperating with the impeller rings to form fine circumferentially disposed clearances between the stationary casing means and the rotating impeller on each side thereof, for restraining the escape of the said liquid, said rings being substantially smaller than the impeller diameter, and said impeller periphery at the discharge passage ends having a large peripheral clearance with respect to said casing means and thereby providing for the free flow of pressure liquid in passing from the central chamber to each side chamber, circumferentially spaced orifices passing through the impeller from side to side at a diameter slightly greater than that of the inner diameter of the wearing rings, said orifices being isolated from said laterally enclosed passages to provide free communication between the said two backflow side chambers, the said peripheral clearances effecting side wall pressure equalization at and near the impeller perimeter, and the ducts effecting side wall pressure equalization near the ring clearances, whereby the resultant axial forces due to liquid pressure on the impeller sides exterior of the wearing ring clearances are substantially balanced, and independent means connected to said fluid supply and to the surfaces of the rings disposed at the side of the impeller away from the impeller eye for balancing the axial forces due to liquid pressure acting on the said impeller at points situated diametrically within the said wearing ring clearances.

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