INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1893-4.

President: W. H. WHITE, Esq., C.B., LL.D.

FIFTIETH PAPER

(OF TRANSACTIONS)

PUMP VALVES

BY

Mr. W. E. LILLY

(ASSOCIATE MEMBER.)

Read at 58, Romford Road, Stratford, E., on Monday, January 8th, 1894.

Discussion continued on Monday, January 22nd, 1894.

Read at the University College, Cardiff, on Thursday, January 18th, 1894.

58, ROMFORD ROAD,

STRATFORD, E.

January 22nd, 1894.

PREFACE.

A Meeting of the Institute of Marine Engineers was held here this evening, presided over by Mr. J. R. Ruthven *(Member of Council)*, when a Paper on "Pump Valves," by Mr. W. E. Lilly *(Associate Member)*, was discussed.

The Paper was read by the Author at the meeting held on Monday, January 8th, when Mr. Ruthven also presided.

A Meeting of the Bristol Channel centre, presided over by Professor A. C. Elliott, D.Sc. *(President Bristol Channel Centre)*, was held in the University College, Cardiff, on Thursday, January 18th, when this Paper was also read and discussed.

JAS. ADAMSON,

Honorary Secretary.

INSTITUTE OF MARINE ENGINEERS

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President—W. H. WHITE, Esq., C.B., LL.D.

PUMP VALVES

BY

MR. W. E. LILLY

(ASSOCIATE MEMBER.)

READ AT 58, ROMFORD ROAD, STRATFORD,

On MONDAY, JANUARY 8th.

DISCUSSION

On MONDAY, JANUARY 22nd, 1894.

READ AT

THE UNIVERSITY COLLEGE, CARDIFF,

On THURSDAY, JANUARY 18th, 1894.

PUMP VALVES.

The subject of this paper, usually considered an elementary one, is, however, of much interest, and worthy of the consideration of engineers, who, in the present day, to effect any economies in the steam engine, find it is rather by attention to details than to any radical change in the design of the engine itself that the highest efficiency is obtained. Pumps being a necessary adjunct to every condensing engine, and absorbing as they do a large amount of mechanical power to drive them, engineers naturally try to reduce the loss under this head to a minimum, and to obtain this result it is necessary to consider the pump valves, bearing as they do in such a marked manner upon the efficiency of the pumps. To determine, then, what is the best style of valves for a pump, it will be necessary to consider what is required of the pump, and what are the conditions under which it has to work; and this leads us first to consider the different kinds of pumps. All pumps requiring valves may practically be classed as reciprocating pumps, and these again, for the purposes of this paper, have been sub-divided as follows (figs. 1, 2, 3):—

PLUNGER PUMPS, such as feed pumps;

PISTON, OR DOUBLE ACTING PUMPS, such as combined steam pumps, and some forms of circulating pumps;

BUCKET PUMPS, as generally used for air and circulating pumps.

Among other desiderata required for pumps, the following are practically general for all. They should have a good efficiency under varying conditions of speed and work, and should run free from noise or shocks, and require few repairs. In what follows, water, in all cases, has been assumed as the liquid to be pumped, its viscosity being neglected. To determine the dimensions of a pump of a required capacity, if Q is the quantity of water in cubic feet to be pumped per minute, N the number of strokes per minute, and L the length of the stroke in feet, then:—

$$\text{Capacity of pump} = \frac{Q}{N}$$

and

$$\text{Diameter of pump} = 13{\cdot}55\sqrt{\frac{Q}{N \times L}}\ \text{inches.}$$

The above formulæ are general for all cases, N having double the value for piston pumps as compared with plunger or bucket pumps, and as it is impossible in practice for a pump to work up to its theoretical capacity, let Q be multiplied by some constant so as to obtain the practical capacity for the required quantity Q. Assuming the efficiency as known, the following table gives the values of the constant required :—

Efficiency %	50	60	70	75	80	85	90	95
Values of K	2	1·67	1·43	1·33	1·25	1.18	1·11	1·05

Referring to the piston pump, as shown in Fig. 2, the piston speed in feet per minute will be equal to the stroke in feet multiplied by the number of strokes per minute, this is the average piston speed, but does not represent the maximum speed of the piston during the stroke. If the piston be supposed to be connected similarly as is the steam piston to a shaft rotating uniformly, the speed will vary from nothing at the commencement of the stroke to a maximum towards the middle of the stroke, and this maximum can be shown to be approximately half as much again as the average speed. The above applies equally to plunger or bucket pumps. In Figures 1 and 2 are shown a piston and a plunger pump, if the valves are supposed to be arranged as there shown and the stroke just commencing, ing, water will flow into the pump due to the difference of pressure in the pump chamber and the outside source of supply, similarly on the return stroke, water flows out of the pump, due to the difference of pressure in the pump chamber and the vessel into which it delivers; this volume of water then is set in motion in opposite directions every double stroke. Should the valves be at some distance from the pump chamber, as shown exaggerated in Fig. 1A., a volume of water in the passages is also set in motion in opposite directions every double stroke and this to no useful purpose; to avoid this it is advisable, and might almost be stated as an axiom, that "there should be as little clearance as possible between the pump chamber and the valves." Some objections may be raised that the water external to the pump-chamber has also to be set in motion, and the closeness of the valves is not of such consideration; to overcome this it is usual to fit air vessels close to the valves or to arrange that the water in the supply and delivery shall be continually flowing toward and from the pump chamber respectively, the object in both cases being to give motion to as small a quantity of water as possible, beyond that required by the pump at each stroke. Another reason for having as little clearance as possible, which is specially applicable to air pumps, is that the clearance space, by allowing vapour to form, causes the efficiency of the pump to be impaired. The positions of the valves with regard to the pump chamber might be multiplied almost indefinitely and depends in a great measure on the position of the pump itself, the valves being usually arranged so that their own weight helps to close them.

Some pumps are made with a pump chamber of larger size than the plunger, so that a volume of idle water is in the pump, by this means it is possible to overcome the objections of having a volume of water reciprocating to and fro in the passages, and, at the same time, secure favourable positions and plenty of space for the valves, which can be arranged on the pump chamber itself—the disadvantage this has, is, that in pumping hot water, if the difference of pressure between the pump chamber and the supply or delivery be appreciable, vapour is formed, which impairs the efficiency of the pump.

In reciprocating piston and plunger pumps, the continual change of direction of the water in and out of the pump chamber acts disadvantageously against any great piston speed. If the piston in Fig. 2 be supposed to be moving with a quick speed, the difference of pressure between the pump chamber and the outside source of supply will be greater than if it were moving with a slow speed, and this difference of pressure will vary approximately as the square of the speed, also the water, owing to its inertia, will have to be acted on for an appreciable time by the difference of pressure to give it the required velocity of flow into the pump chamber. Suppose then the piston speed to be continually increased, a speed will be arrived at in which the pump chamber will be only partially filled with water, the water not having time to acquire sufficient velocity to follow the piston ; in such a case the pump chamber may be about half filled with water, on the return stroke the piston descends and meets the water ; it will, at this moment, have its maximum velocity during the stroke and all the water in the pump chamber will have to acquire this velocity instantaneously, together with the pressure necessary to drive it through the valves into the delivery, something then of the nature of a blow must take place which cannot be otherwise than detrimental to the action of the pump, and it is due to these causes that the difficulty of making high speed piston pumps arises ; the energy wasted increasing as the piston speed and the number of reciprocations increase, the strains on the working parts being greater, and the pump falling off in efficiency. Water-works Engineers—in charge of the water supply to the different towns in this country—seem to have been alive to this difficulty and to have discarded this form of pump, using the bucket pump in preference.

Bucket pumps have a great advantage, as compared with piston or plunger pumps, in this respect, that the direction of the flow never changes and the difference of pressure required is only that necessary to drive the water through the valves. Supposing a similar case to occur, as in the piston pump, where the pump chamber is only half filled with water, on the bucket meeting the water,only the surface of the water is affected, as shown in Fig. 4, thus relieving the pump and permitting of a more efficient pump at high piston speeds, and no doubt one of the reasons for this form of pump being in favour with marine engineers, is, that should the engines race or the pump only become partially filled, due to the rolling of the ship, it is not so liable to breakdonw or labour so heavily as other forms of reciprocating pumps.

Having thus briefly reviewed the working of the pump, the best conditions for the pump valve will now be considered :—

(1) The area through the valve seats should be as large as possible—various authorities give the velocity of flow through the valve from 400 to 600 feet per min., which corresponds to a difference of pressure from one to two pounds between the pump chamber and the source of supply or delivery. To calculate for this velocity of flow let S = the piston speed of pump in feet per minute—s = the velocity of flow through valves from 400 to 600 feet per minute. A = the area of pump chamber in square inches and a = area through valve seats in square inches then :—

$$\frac{S}{s} = \frac{a}{A}; \quad \text{or } a = \frac{S\,A}{s} = \frac{S \times A}{450}.$$

In designing the area through the valve seats, the conditions under which the pump will be required to work must be considered, since, for the water to flow into the pump, an amount of energy has to be expended in giving the necessary velocity to the water to flow into the pump, and that this energy expended varies as the square of the velocity; also, if the strokes per minute are constant, the expended energy will have to be given to the water in equal times, and it follows that the difference of pressure will vary as the square of the velocity; from this then, it will be evident that in fast running pumps the area through the valves should be as large as possible.

(2) The area through the opening, due to the lift of the valves, should be equal to the area through the valve seats, this might almost be said to be self evident, and yet it is one of those things most overlooked in pumps, the lift as a rule not being sufficient—the real area through the valves in this case is the opening through the lift of the valves, and the area of the valve seat might be reduced to that area without throwing any more work on the pump. The practice of engineers who will not give large lifts to the valves, shows clearly the

necessity of designing valves so that only a small lift is necessary; to give a large lift to a valve means a large amount of wear and tear, whereas if the lift given to a valve is not what it was designed for, it means that extra work is to be thrown on the engines to work the pump,—a result not to be desired.

(3) The valves should always be as light as possible. Referring to Fig. 2, if the piston be supposed just at the commencement of the stroke, the delivery valve closed and the suction valve just upon opening, it will require a certain amount of energy to move the valve off the seat; a small portion of the stroke will take place before there is any motion of the valve, then, owing to the increasing difference of pressure, the valve moves with an increasing velocity till it meets the stop, where it gives up its energy of velocity in striking the stop; this kinetic energy will be proportional to the weight of the valve and to the square of the velocity. Similarly, on the down stroke the valve closes, striking the seat, but in this case its kinetic energy may be greater owing to the fact that the pressure in the pump chamber rapidly augments to drive the water through the delivery valve. The action of the delivery valve will also be precisely the same. If then the valves be heavy it follows that the wear and tear due to hammering or striking will be great, also that the valve itself will be sluggish owing to its inertia; to avoid this therefore, the valves should be as light as possible.

(4) The lift of the valves should be small. Suppose a pump having valves whose weights are the same, but one valve with twice the lift of the other, the valves with the greater lift will have the greater velocity on striking the stop or valve seat, and the kinetic energy will be approximately twice as much as the one with the smaller lift, also it is important for the valves to open and close quickly and the less the lift the better will these conditions be satisfied.

(5) The diameter of the valves should be small, annular, or the equivalent of having several small valves

in one set. The area of the valve seat varies as the square of the diameter, while, the lift of the valve remaining the the same, the area of the opening varies as the diameter only; therefore, if the diameter of the valve be doubled it is necessary to double the lift, as will be seen from the following table :—

Diameter of valve seat	$1\frac{1}{2}$	3	$4\frac{1}{2}$	6	$7\frac{1}{2}$	9ins.
Area of valve in sq. ins.	1·77	7	15·9	28·3	44·17	63·6
Required lift of valve	$\frac{3}{8}$	$\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{1}{2}$	$1\frac{1}{8}$	2ins.

The valves should be so designed as to offer as little opportunity as possible for dirt or other obstructions to get in the way of the working of the same, and lest any dirt should get on the faces, the valves should be made so that in working they tend to clear themselves. It is difficult to lay down any rules to be followed in this respect. For metal valves of rigid section a minimum of bearing surface with a good guide seems desirable. For light metal valves, which are more or less elastic in their working, the guide for the valve is not so necessary, their liability to stick not being the same as with the rigid valves. With many other points in connection with pumps, practical experience alone determines what is best to meet different conditions.

The reduction of area in the valve seats, due to the grids, has been neglected in the above table, which, if considered, would cause the lift of the valve to be rather less than that given; but from what has already been mentioned with regard to the lift of the valves, it will be noticed that the lift becomes excessive for large diameters, and if the valves are at all heavy a large amount of wear and tear must take place.

The above conditions give some guide in determining the best forms for valves, but much is still left to the discretion of the designer in choosing that valve which will give the best results according to the conditions under which the pump will have to work. The plethora of good valves now before the public, each having some special point, makes the choice of the one to be selected for a particular purpose, one of great nicety and discrimination.

Engineers in the early days of steam used leather valves, commonly known as the flap or butterfly valves, these then gave way to metal flap valves (Fig. A), the idea of the flap seeming, obviously, to have been taken from the leather valve then in use, and no doubt these valves worked well in the days of low pressure and slow piston speeds. The rubber valves were next introduced, and so long as they had not to pump against any great pressure, and were kept free from oil, left little to be desired in their working, even to the present time holding their own in circulating and such like pumps. Oil having a solvent action on the rubber, they were found to rapidly deteriorate in the air pumps. Attempts have been made to make the rubber impervious to oil, but, up to the present, unsuccessfully. Vulcanite (a hardened preparation of rubber), fibre, asbestos, cast metal valves of various types, thin rolled phosphor bronze followed, the tendency being, as the piston speeds and pressure kept on increasing, for the valves to be lighter and of stronger section. Figs. A, B, C, &c. show examples of the more generally known valves now in use.

Ball Valve (Fig. B), a metal ball, resting on a like metal seat, is still used for checks and small feed pumps, and owing to its continual movement on the seat keeps very tight, it is a heavy form of valve and takes up a lot of room, especially for the larger sizes.

Wing Valve (Fig. C), Spindle Valve, (Fig. D) are two forms of valves almost universally used for feed pumps and other like pumps, and, for small diameters, seem to be all that is necessary, the bearing surface being flat or bevelled, according to fancy. More often than not, they are made unnecessarily heavy, giving rise to the unpleasant hammering on the seats, so often heard in quick reciprocating pumps. For larger diameters their lift becomes excessive, aggravating the evil just referred to.

Wooden Valves (Fig. E) were at one time tried, to reduce the noise and hammering on the valve seats. A light metal casting, faced with boxwood, and secured by screws, was used. Experience seems to have decided against them, and at the present time are seldom heard of.

Reid's Spindless Metallic Valves (Fig. F) have been designed to overcome the excessive lift with larger sizes of valves, the valves in this case being annular, having two distinct openings, thus securing large area of opening with short lift. Being self-contained, and requiring no spindles, they are not liable to stick or get out of order. These seem to be a move in the right direction. Being light, and having a small lift, the wear and tear is reduced to a minimum. These are also made in larger sizes for circulating and air pumps.

Flat Circular Valves (Fig. G), usually made of gun metal, and of light section, being guided by a central spindle, or stud, are now much used, especially in high-class combined steam pumps. Being of small diameter, light, having large bearing surface, and being quick in their action, they are winning much favour with engineers. A spring is sometimes fitted on the back of the valve to ensure quick return ; but if the valves are kept of small diameter, so as to require only a small lift, there seems to be no necessity for the spring.

Thompson's Phosphor Bronze Valves (Fig. H) are of light and strong section, and of small diameter, mounted on a central stud, and being strong and rigid, no doubt work well. These valves are also used for circulating and like reciprocating pumps.

Hawks' Davey's improved) Patent Conical Valves (Fig. I) are cast metal valves, of conical section, mounted on a central stud, of strong and light section, work well, provided the diameter is not large. They have been successfully used in various kinds of pumps, the water in flowing through these valves, passes into the pump with less friction than ordinary flat valves, the conical recess at the bottom of the stud being continuously filled with water, acts as a cushion on the return stroke of the valve.

Annular Valves (Fig. J), composed of light concentric rings, were designed to give a valve of small lift and large opening. They have worked well, and it is a matter of some surprise that their use has not extended more among engineers, giving, as they do, a light form of valve for air and circulating pumps, the lift being small and the wear and tear slight. A series of these valves were designed, in which the lift was the same for all sizes—three-eighths of an inch.

Rubber Valves (Figs. K and L), circular or rectangular in shape, secured at the centre by studs to the valve seat, the guards being fixed to the studs to limit the opening of the valve to the required lift. They are principally used for circulating pumps. Where the pressures are at all great, a thicker form of valve is sometimes used, as shown in Fig. M, the valve in this case not being secured to the central stud, but only being guided by it, the guard, as before, limiting the opening to that required. Some American Engineers still use a valve of this type in feed and other high pressure pumps. As has already been stated, for circulating and such like pumps these valves still hold their own.

Vulcanite Valves (Fig. N) were formerly used, but at the present time do not seem to be much in use—a circular disc guided by a central stud, having a guard to limit the opening and a grid for the valve seat, these valves were light and quiet in working.

Fibre Valves (Fig. O, have been in the market some years, the makers claiming for them advantages over rubber valves; the method of securing them is similar to that for rubber valves; their lightness is in their favour.

Beldam's Corrugated Valves (Fig. P) are circular metal valves of light and strong section and have obtained a good name. They are fixed similarly to many others, being guided by a central spindle, the lift being controlled by a guard, they are light and quiet and seem specially suitable for air and circulating pumps; as with other valves, having only one opening with large diameters, the lift is excessive.

Kinghorn's Flexible Phosphor Bronze Valves (Fig. Q) would seem to be a direct descendant of the old butterfly valves, the flaps in this case being thin plates of rolled phosphor bronze, resting on a grid for the valve seat, and the guards being of a curved shape so as to allow the valve to open and bend round them without any sharp change of flexture, they are are ideal valves in some respects, being light, the wear and tear a minimum, and for air and circulating pumps have given great satisfaction.

Kinghorn's Mutiplex Valves (Fig. R) are formed by a series of three thin metal discs resting on top of one another, guided by a central stud and having a guard to control the lift. The discs are of thin rolled metal,and no doubt give very free openings. These valves are specially suitable for air and circulating pumps, and have also been used successfully in feed pumps.

Flap Valves (Fig. S) are still used for bilge pumps, and in a few other slow running pumps; they have the advantage that they are easily cleaned and taken adrift.

In conclusion, the author hopes that in bringing a paper on this subject before the Institute, many of the members will contribute particulars of any further valves that may not have been mentioned, so that the particulars of the valves given may fairly cover the ground, as represented by modern practice, and at the same time give the benefit of their experience in the working of Pumps and Pump Valves, that the merits and demerits may be gauged in the result.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1893-94

President:

SIR THOS. SUTHERLAND, K.C.M.G., M.P.

DISCUSSION

ON

"PUMP VALVES."

AT

58, ROMFORD ROAD, STRATFORD,

ON

MONDAY, JANUARY 8th, 1894.

CHAIRMAN:

MR. J. R. RUTHVEN *(Member of Council).*

The CHAIRMAN: Mr. Lilly has in the paper just read, gone very fully into most of the points in regard to the styles of pumps, also of valves, to the relative positions of the different parts, and also to the renewal of the wearable parts, and the velocity of the water. The question of the concussion on the pumps and the valves is a very important one, and one which it is very difficult to follow out in practice. The change in the direction of the water and the loss of power by the concussion are very interesting points, and well worthy of discussion and investigation; many of the matters referred to in the paper cannot always be gauged accurately, but with the varied experience of those using various pumps I think a very good idea can be obtained as to the best valve for any particular purpose. The difficulty is to get a valve that will answer every purpose. I now invite you to discuss any point that may occur to you in regard to this paper; important points involved are, the manufacture, the wear and tear, and the facilities for renewal under all conditions of working.

Mr. JAMES ADAMSON (Hon. Secretary): Before the meeting commenced we had a discussion in the reading room as to the lifts of pump valves, and I think that this is a point which might bring forth a good many expressions of opinion. Mr. Lilly has given us some high lifts for valves, and I dare say that most of us will differ very much from the figures he has set out in this respect. I would suggest that members should give expression to their views as to whether valves should in practice have the lifts which Mr. Lilly indicates. With regard to the weight of the valves, that is a matter which may depend a good deal upon whether the valves are supplied by a repairing shop or by the original builders. Reference is also made in the paper to wooden valves, and I note that Mr. Lilly has not alluded to lignum vitæ valves, which are used much the same as the boxwod. Lignum vitæ valves have been working very satisfactorily for the last ten years in one or two ships that I know of. The lignum vitæ requires renewing occasionally, but they seem to last very well in donkey pumps. With regard to Beldam's valve, the cushioning action is also used. Where the valves are double banked, one valve is made with holes in it, so as to give the effect of cushioning. I think it would be extremely interesting if we could ascertain what the different makers of india-rubber valves use for their air pump mixtures. Every maker has an idea of his own as to what the mixture ought to be, but the makers of some valves seem to have hit upon the proper thing, while others again have not. We find that an air pump rubber valve lasts only one voyage in one ship, and three or four voyages in another; why should there be such a difference between the valves of different or even of the same makers, especially in these days when chemists are attached to every rubber factory, and every maker can analyse and ascertain what is in his rival's valves, and the curing can be seen to exactly in each lot? I do not think that we have much difficulty with circulating pump valves, so far as the rubber is concerned, granting a reasonable price is paid, but here again we find that some valves may run for 12 or 18 months, or longer, whilst others go in a voyage. Beldam's valves have proved to be more satisfactory than the rubber where introduced in several steamers of which I am aware, they have proved themselves to be more durable. In one steamer where those valves were fitted about eight years ago, the renewals have been few and far between. I am aware, however, of two cases where they have failed; the studs gave way, resulting in the valves breaking, thus showing the necessity for stronger studs for metal valves, and a cushioning action to prevent the jarring which at times comes on the pumps. Kinghorn's valves are also very good as substitutes for rubber; I know more than one steamer where it has been mentioned to me they work very efficiently. There had been some trouble with the single valves, but since they have been double banked they have done better. Fibre valves are also well spoken of; several instances have been brought to my notice where they have proved very efficient and satisfactory.

Mr. A. ROBERTSON (Member): I have had some experience of the use of the American fibre valves in air pumps, and as long as the engines were working they answered all right, but when the ship went into port and the engines were at rest they got dry and curled up, in consequence of this we took the valves out when the vessel got into port and put them into water to keep them in working order. I also had some experience of Kinghorn's valves which worked very well.

Mr. J. B. JOHNSTON (Member): In regulating the lift of valves practice in most cases upsets theory. The strict letter of the Board of Trade rules and the rules followed in the drawing offices may be theoretically correct, but they are practically impossible; under certain conditions, practice and experience should be the guide at all times. Where a fourth of the diameter is given for lift an eighth in many instances is sufficient, as pumps are generally constructed in duplicate, each to do the work of two in the case of either breaking down. With regard to feed pump valves, the ordinary wing valves with flat seats are the best I know of, but builders sometimes do not always put in sufficient metal, and it is sometimes not of the best quality. As to the weight of valves and the question of wear and tear, a light valve might wear out a valve seat as much as a heavy valve, depending on their conditions of working. I consider that a good rubber mixture, made by an experienced firm, is very efficient; pure rubber would not at all times answer the purpose, it would not resist the various temperatures, the chemicals in the oils, or the foreign matter introduced into pumps. I consider fibre valves a great improvement on rubber, particularly in air pumps, even if they do curl up when the engines are at rest, a turn of the engines or water circulating through the condenser soon brings them to their working condition. They are about one-third of the weight of ordinary rubber valves. I introduced them to the service with which I was last connected, and during the last three or four years we used nothing else for air pumps, and I believe they are still in use.

Mr. J. G. LATTA (Member of Council): Mr. Lilly has advocated the use of very light valves in all classes of pumps, and seems to favour a valve of the Kinghorn or Beldam pattern; my experience amongst pumps is that the construction of the pump and the work it has to do determine the weight and design of valves to give the greatest satisfaction. With regard to a certain class of pump, I believe it is the very best practice to make the valves as solid and as heavy as possible as they are easier on themselves and also on the seats, and consequently stand longer; but in fast running pumps and air pumps the buckets are best when fitted with light valves such as the Kinghorn or Beldam. Another point I do not see very clearly is Mr. Lilly's statement, that a bucket pump when the suction is limited is less likely to hammer than a double acting plunger pump if the pressures pumped against are the same and the outlets the same size. I can see no difference between the two pumps.

Mr. LILLY: Many points have been raised in the course of the discussion, but I regret that the paper itself and some of the reasons given therein have not been questioned, rather than that the discussion should have had reference to the valves alone. It is obvious that one can say certain pumps work in a particular way with certain results, but we want to ascertain why they do so. I also hoped that some light would have been thrown upon the present practice of engineers in giving small lifts to the valves, very often regardless of the area of the valve seat. As mentioned in the paper, the tendency seems to be to have the lighter and smaller valves with small lift, the valves of those pumps which are well in favour with engineers clearly showing a tendency in this direction. The only place I know of where lignum vitæ valves are used is at a vinegar factory, where it is a necessity, as the metal valves came to pieces; as to india-rubber valves, I agree with Mr. Adamson, that in order to get a good article you must pay a good price, and in the long run it is cheapest to do so. If the piston speed or pressure is not excessive india-rubber valves work well. Mr. Johnston appears somewhat of the opinion that what practical engineers do must be right whether or not they can give reasons for what they do. The object I had in view in writing this paper was to get the opinions of engineers on the subject of pump valves, having found such a diversity of opinion and difference of practice amongst engineers themselves on many of the points mentioned in the paper. I desired, if possible, to eliminate from the many opinions expressed during the discussion the best practice, rather than that of any engineer in particular.

That such diversity of opinion and practice exists is clearly shown by the number of different valves in the market, each having some special merit, yet differing widely from each other; such being the case, it is evident they cannot all be the best, but must be chosen with regard to the purpose for which they are to be used. I omitted mention of Lewis's textile valve, and no doubt have also omitted others, but I should be glad of particulars of any others now before the public, or which were used in times gone by, so as to make the descriptions of the various kinds of valves now in use as complete as possible. In conclusion, I would thank you for the very kind attention and interest you have shown in the paper.

The CHAIRMAN: We have been under a slight disadvantage to-night in not having the paper printed, it is proposed to give another night for the discussion of the subject. The discussion will therefore be adjourned until this night fortnight, the 22nd inst. Mr. Lilly will not be able to be present on that occasion, however.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1893-4.

President:

W. H, WHITE, Esq., C.B., LL.D.

ADJOURNED DISCUSSION

ON

"PUMP VALVES.

AT

58, ROMFORD ROAD, STRATFORD,

On MONDAY, JANUARY 22nd, 1894.

CHAIRMAN:

MR. J. R RUTHVEN *(Member of Council.)*

THE business this evening is the adjourned discussion on Mr. Lilly's paper on "Pump Valves." Mr. Lilly read the paper at our meeting on Monday, the 8th inst., and described all the diagrams you see here on the wall. You have now a rough proof of the paper in your hands, and if you look over it you will find plenty of matter for discussion, both in regard to the different classes of pumps and the different classes of valves. Of course, it is of great importance that the subject should be thoroughly discussed, and I hope we will go into it to-night. The paper deals with the pumps, the valves, and the position of the valves.

With regard to the pump, the style of valves and the facilities for their repair and renewal, the velocity of the water and the question of the concussion of the water. Another question was the destruction of the valves in the lift. Mr. Lilly seemed to think that we ought to have a large lift equal to the area of the valve, but he said it was the general practice to reduce that lift, and he wanted to know why. There is plenty of room for further discussion. I think we ought to begin with the question of the lift—why the lift should be small, and why it generally is small in proportiom to the area of the valve. That seems to be one of the chief points. It is very easy to say what the lift should be for the area of the valve, but it is always less—at least it is preferably less. Another point is whether the valves should be light or heavy. We have here drawings and descriptions of all sorts of valves, and I hope members will say what they know about any of them—what their experience of them has been.

Mr. JAMES ADAMSON (Hon. Secretary): I may say that this paper was read before our Bristol Channel Centre, at Cardiff, on Thursday last, and I think if I read a brief report of what took place at Cardiff, it might suggest some points to the members present which they could criticise or follow out.

BRISTOL CHANNEL CENTRE.

A meeting of the Bristol Channel Centre of the Institute of Marine Engineers was held at the University College, Cardiff, on January 18th, Professor A. C. Elliott, D.Sc., presiding.

In the absence of the author, a paper on "Pump Valves," by Mr. W. E. Lilly, was read by Mr. Robert Davison, and a spirited discussion followed.

Mr. DAVID GIBSON thought that insufficient attention was given generally to pump designs, and many defects might be set right if the drawings were more carefully inspected. It was important to have the valves as light as possible. Some of aluminium had been introduced, and he believed they answered admirably. Too much lift was worse than too little. Rubber was very suitable for pump valves. Small metallic valves, as sometimes used in series on a bucket, were altogether bad, and should never be adopted.

Mr. R. Davison considered a high lift beneficial in pumps running at a great speed, more particularly in donkey pumps. In feed pumps a smaller lift would be sufficient. The first cost of an air pump fitted with small valves would be greater than for a single valve. A foot valve should be fitted to air pumps, so that any mishap to the bucket valves would not materially affect its working.

Mr. James Ferrier was quite in favour of metallic valves in series for air pumps. He had used them for many years, and when properly looked after were more economical than any other form. They were also easily repaired or renewed on board ship. Rubber valves were not worth a consideration in comparison with metallic ones.

Mr. E. Jones was of opinion that metallic valves were inferior to rubber, as they were quickly destroyed by grit. Of course he meant rubber of good quality.

Mr. A. Kendrick approved of metallic valves. In plunger pumps he considered the chamber should be bored right down, the same diameter as the plunger, and no clearance left around the latter. The plunger should also be pointed.

Mr. W. Ball agreed that tapering the end of the plunger would do away with a lot of hammering of the valves.

Mr. J. S. Bond had found Beldam's valves good, and no better than Kinghorn's could be used for air pumps. He never knew ball valves to give any trouble.

Dr. Elliott reviewed the paper generally, and thought the principles in it were pretty well laid down. He would prefer a large circular aperture with a small lift rather than a series of small valves. Pointing the end of the plunger would not, in his opinion, have any good effect.

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Mr. Adamson (continuing): There are several points raised in this report which I think might be productive of a good discussion to-night. On the last occasion some members spoke very much in favour of valves in series, the same as in Weir's pumps. There are 12 or 14 valves all on the one seat, working simultaneously. There were apparently two different opinions expressed at Cardiff as to rubber *versus* metallic valves, and I daresay if the matter were sifted we should find the reason why.

The Chairman: The points raised at last meeting were the different classes of pumps and the different classes of valves. The question was also raised as to what was best for any particular purpose, and the reasons why. The discussion got as far as the rubber and the metallic valves, and a small lift in preference to a large one. There were two opinions on this question of lift at Cardiff—one speaker preferred a great lift and another a small one. Of course the question of repairs is also most important, perhaps more important than anything else. Then there is the point as to the weight of the valve, whether it should be light or heavy. Another point: the destruction of the valve, and the fact that a small lift tends to prevent hammering seems to me a strong reason why large lifts should not be allowed. Mr. Lilly said that if you gave the valve a small lift you increased the velocity of the water, which absorbed a great deal of power, but I think this is quite a matter of minor importance, and that the loss of power in driving the water faster is very small.

Mr. H. C. WILSON (Member): Not having heard the paper read, nor the discussion which followed, I am not quite in a position to offer much criticism. The subject of pumps has always been an interesting one to me, and I am sure that their efficient working at sea makes just the difference between a comfortable ship and the reverse, at least as far as the work of the watch goes. With regard to the different forms of pump valves, I quite agree with Mr. Lilly that the designer must first consider the purpose of the pump before deciding on the type of valve to put into it. The ball valve I consider to be about the best type for feed pumps, especially when the engine is of the triple expansion type. I have always found them to be a very tight valve, and if kept clean they are not liable to form flats on the valves. They certainly occupy a good deal of room, on account of the necessary cage over them, but the lift can be set to a nicety, and the wear and tear and repairs are very small. For a bilge pump of the vertical plunger type the choice of valves is somewhat difficult, as this pump in any ship is the one with the greatest difficulties to contend against. The wear and tear is very great, owing to the nature of the bilge contents, and consequently the valves have anything but favourable conditions to work under. However, I should prefer a valve which would allow of the greatest area through the seating—say a spindle valve; but the choice so much depends upon the position, &c., of the pump that one cannot say decidedly which ought to be used, but rather those types which ought not. For instance, two rubber valves, one above the other, on the same spindle, having small grids for seats, is a most unsatisfactory arrangement; the slightest obstruction lodging on either grid necessitates taking out the whole of the valves, seats, stops, spindles, &c., and breaking all joints. I have found brass flap valves work very well, but they soon wear out, as the edge of the valve most remote from the trunnion or hinge wears faster than the part nearer to it, and so impairs the efficiency of the pump. For a circulating pump I do not know of anything better than india-rubber valves arranged in sets if the pump is large, but in any case the valves should close with their own weight and be free on the studs. I have found this sort of valve work well, and any repairs or renewals can be quickly and easily done. The air pump presents some difficulties on account of the temperature of the water and the almost unavoidable presence of oils of one sort or another. I consider rubber valves wholly unsuitable, and certainly prefer a good fibre valve to a metallic one. In this pump the type of valves is not so much to be looked at as the material of which it is composed. I also prefer the foot valve to be a single one, as any one who has spent hours headforemost down an air pump, taking out and replacing a number of small valves will easily understand. I think that too much attention cannot be paid to the design of guards for this type of valve, as I am sure the life and reliable working of the valve are largely dependent upon the suitability of the stop or guard. Just a word on the lifts one usually finds given to valves. I think I am not far out in saying that at least 60 per cent. too high a lift is given, and I am afraid that this is a good instance of the difference between theory and practice. Of course the area of escape should be equal at least to that of the seating, but this is too often obtained by allowing an excessive lift which, in the case of heavy valves and quick speeds, soon destroys them.

Mr. J. H. THOMSON (Member of Council): In reading over the report on Mr. Lilly's paper last week, I could not help remarking to myself that his ideas in reference to pumps were very similar to my own. Of course, there are so many different kinds of pumps, and each one has its peculiarity. For a force pump similar to that shown in Fig. 1, I quite agree with Mr. Lilly that the greatest efficiency will be gained by having the valve box close up instead of allowing a long passage between the valve box and the pump chamber. From a theoretical point of view it may appear that a pump will work well with this passage, but the manager of the works where I served my time strongly impressed it upon me that the valves should always be placed as close to the plunger as possible, so that my ideas have since run in that groove, yet in my experience I have seen some splendid working pumps with the valve box just about as far removed from the plunger as possible —about half the width of the ship. There is a vessel in the harbour now that has got a bilge pump, the plunger of which is directly off the cross head, and the valve box is in the wing of the ship, so that there is a column of water passing backwards and forwards all the time. When once you have got the vacuum and got the water it is one long plunger. I quite agree with the speaker at Cardiff who said that there ought to be no clearance on the side of the plunger—only a working clearance--but I cannot follow him when he says that the plunger should be pointed. I cannot see that the shape of the end of the plunger makes any difference. It is really a question of displacement, and I do not believe that the shape of the end of the plunger makes the slightest difference Now, with reference to the valves. My idea is that the area of the valve should exceed the area of the plunger considerably, because by this arrangement you can reduce the lift of the valve. You can get the same volume of water through the valve without the theoretical amount of lift. By reducing the lift, the valve acts more quickly, and there is less wear and tear upon it. I will give you an instance that came under my own notice. In a vessel in which I was once engaged there was a complaint of a deficiency of water to the baths, and an extra pump was fitted. It was a double acting pump of about three inches diameter and nine-inch stroke. After being fitted, it worked very well on the first day, on the second day it fell off, and on the third it was worse. On the arrival of the ship at its first port of call, this part of the voyage having only occupied three days, I had the pump taken to pieces, when I found that it had been very awkwardly put together. I found that each of the valves had been fitted according to the correct theoretical data, and in accordance, I was told, with the Board of Trade rule. Each valve had a lift equal to the area of the valve. The consequence was that these valves were all hammered to pieces in three days owing to excessive lift. Had the valve seats been made twice the area and the lift reduced one half they certainly would not have been knocked to pieces so soon. When we got to the next port in another two days I had the lifts of all the valves reduced to about one-eighth of an inch, with the result that we got plenty of water and we had no trouble with the pump afterwards. On my return I had a conversation with the designer of the pump, and I said to him, "You gave your valves far too much lift," but he denied that he had done anything of the kind, and referred me to the Board of Trade papers.* If pump makers would make the valves of larger proportion, and reduce the lift, the result would be a more efficient pump. In reference to air pumps, the only valves that I have sailed with have been rubber valves, and I have never had any trouble with them. I once suggested to the assistant superintendent that it would be a good thing to try metal valves—I think it was Kinghorn's—but he replied, "They are very good valves as long as they last, but the awkward thing about them is that the very time you want them is the very time they will give way. You may find that the whole lot of the valves will carry away just as you are leaving harbour."

There is one thing I should like to mention about air pumps and circulating pumps, and that is that many engineers seem to make a great mistake in trying to get the buckets too tight. Some engineers used to think that the tighter you got them the better the action, and I know one case where they got a special ram so as to force the bucket into its place, but the result was a breakdown on several occasions; any advantage they got in the way of vacuum was very doubtful. I have never been ship-mates with ball valves, but they generally want a cage over them, and one of the difficulties about them is the work in getting them

* The old papers referred to here can only be taken to state the lift by reference.

truly spherical. With regard to the weight of valves, I consider that a valve ought to be made as light as possible for the work it has to do. The heavier the valve the greater the work in lifting it, and the greater the wear and tear, that is my opinion. Dr. Elliott, at Cardiff, said that pointing the end of the plunger would not have any good effect, and I quite agree with him.

Mr. GREER (Member): Practical experience of pump valves shows that with large lifts you get hammering, and the only way to overcome that is by having a large area and a small lift. Apart from the question of cost, there is no valve equal to a rubber valve for sweet working. With regard to the shape of the end of the plunger, I should say that in some pumps it is quite immaterial what form is adopted; but in those pumps where the plunger comes down into the water I think a pointed plunger would be an advantage.

Mr. WATSON (Member): I certainly agree with Mr. Thomson as regards the pump chamber being made the same size as the plunger, and with reference to valves I have found fibre valves very efficient. I have known cases where they have worked well for three years. Cocoanut fibre valves I think they are called. On the question of the lift of valves, especially as regards feed pumps, I think the less lift you can give them the better—that is, provided the area is sufficient for the size of the ram.

Mr. GREER: In some pumps made by Armstrong in connection with the hydraulic gear at the Surrey Commercial Docks, where there is great pressure, there are no stops at all; the valves give their own lift, and the water gets away as fast as it comes.

Mr. J. H. THOMSON: There must be a stop somewhere.

Mr. GREER: No, there are no stops to them. They never strike the stops at any period of the motion of the pump.

The CHAIRMAN: On the question of having the pump chamber the same size as the plunger, you can answer the same purpose by taking the valve box off immediately under the neck bush, because by that means you drive the air out in the first instance. The object of having the chamber the same size as the plunger is to prevent an accumulation of air, especially in feed pumps, and I would much rather see the valve box immediately under the neck bush. Get the air out first, and you are bound to have air unless you have good packing, however well it is bored.

Mr. H. C. WILSON: I should like to ask if any gentleman present can explain the action of the Pulsometer. It is a ball valve, I believe, and I have my own ideas about it, but I should like to hear its action explained.

Mr. JAMES ADAMSON: I was in hopes that we should have had a representative of the Pulsometer Co. present this evening to give us a description of their pump, but apparently he has not been able to attend.

Mr. WILSON: I do not know whether there is anything in the paper about admitting air after you have started the pump, but if you give it no air at all serious trouble often arises.

Mr. J. H. THOMSON: The question of air vessels is a very important one. Sometimes it is a matter that is neglected, and you often hear of them being fitted after the ship has been running for a time.

The CHAIRMAN: It is rather surprising to me that there has been no attempt to make a valve similar to what we have in our own hearts. I know that there have been rubber valves of that description, but I never saw a metal one of the kind.

Mr. JAMES ADAMSON: I think there is one point that we are all agreed upon, and that is that the valve box ought to be as near as possible to the plunger. A long passage between the bottom of the plunger and the valve is a very objectionable feature, inasmuch as the further the valve is away from the plunger the more idle water there is. I fancy that in the case cited by Mr. Thomson the pipes would go pretty quickly, owing to the friction caused by the water rushing through them. Mr. Wilson has called attention to a matter that has given rise to much trouble in connection with pumps, namely, the want of proper air valves. I have met cases where more air had to be put into the pump than the air valve would admit, and when more air was admitted the pump ceased to give trouble. Another point I think we are all agreed upon is, that a large area and small lift are preferable to a small area and large lift. In the cases referred to by Mr. Lilly the lift had to be all that the area required, but as a rule I think pump valves are given a larger area so that we can afford to keep the lift small, and thus avoid the hammering action. With regard to the proposal to make the plunger pointed or cone-shaped, the object in view was to reduce the shock caused when the end comes down on top of the water if the water does not fill the chamber. By making the plunger pointed you do not get such a shock when it meets the water. There is one thing that is most reprehensible, and that is putting upon a single pipe the work of two or three pipes. A case has occurred where the ballast donkey and the bilge pump sucked through the same pipe, the object being, of course, to save a pipe. The ballast pipe was carried right through the ship, and the bilge suction was led into it, so that there was only the one pipe to do the double work. I noticed about a fortnight ago that an accident had happened to a ship which was apparently fitted in this way. Some of the valves had been opened, and instead of pumping water out of the ship they were actually pumping water into it through the ballast pipe. It appears a very nice arrangement when seen in the drawing office with the different pipes branching off at intervals, but when it comes to ship's work it leads to trouble. With regard to the different opinions expressed at Cardiff as to these metal valves, it is probable that the difference was possibly due to the same cause as I alluded to a fortnight ago. I said I had known steamers that had been fitted with Beldam's valves, and that they had been running very satisfactorily for seven or eight years without any necessity for renewing more than about six of them in that time, whereas in another ship the same kind of valves carried away before she got to Port Said. It was the studs that gave way, and possibly the adverse opinion expressed by the speaker at Cardiff in regard to metal valves was due to a similar experience. In the one case the studs were strong enough and the valves worked very comfortably for years. I believe that in Kinghorn's valves now they put three flats, the lowest one has perhaps half a dozen holes in it, the second three or four, and the top one none, the object being to prevent the valve from splitting. I know many ships that are fitted with them and they worked very well indeed, but they work all the better when they were double banked. Lewis's textile valves have been referred to. I had one trial of them and they certainly were not a success. The fibre valves are first rate valves, indeed they seem to be favourites in the market just now, as far as I can gather.

Mr. J. H. Thomson: I think that a great many of these different results in the working of valves are due to differences in the areas of the valves in proportion to the lift. Mr. Adamson has just told us that in one ship a particular kind of valve did very well, while in another ship it did not, and possibly the fault in the case of the one that did not was, that the area of the valve had not been sufficient, so that a greater strain was thrown upon the studs. In the case of the valve that was satisfactory, I should imagine that the area was of suitable proportion. It is not always the valve itself that is to blame, but the difference in the area for the work that has to be done.

Mr. H. C. Wilson: With regard to the best form for the end of a vertical or bilge pump plunger, I fail to see any advantage in making it conical or pointed, as I think it almost impossible for the plunger of this sort of pump to strike the water with anything like a blow. The air contained in the pump chamber is always on the top of the water, and is subject to the same compression upon the down stroke of the plunger. It would therefore act as an elastic cushion to prevent anything like a shock, providing, of course, that the pump was not being driven at an excessive speed, which, as Mr. Lilly says, would not allow of the water getting in fast enough to follow the plunger on the up stroke. I do not think that the end of the plunger touches the water at all, and it does not matter what shape you make the end of the plunger.

Mr. JOHNSTON: I still consider that for feed pumps and bilge pumps nothing has come up to the wing valve with flat seats, and that for air and circulating pumps, both for efficiency and cost, fibre has 50 % advantage over rubber.

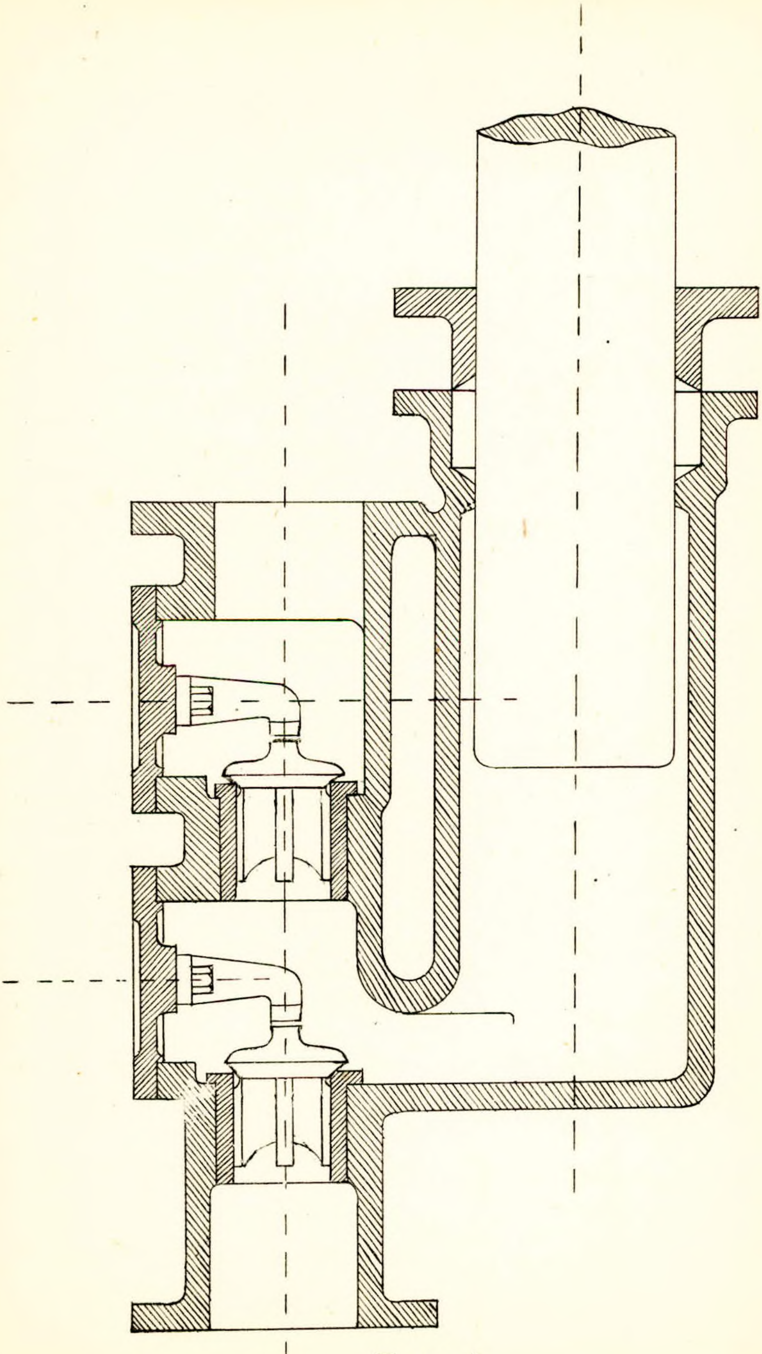


FIG I.

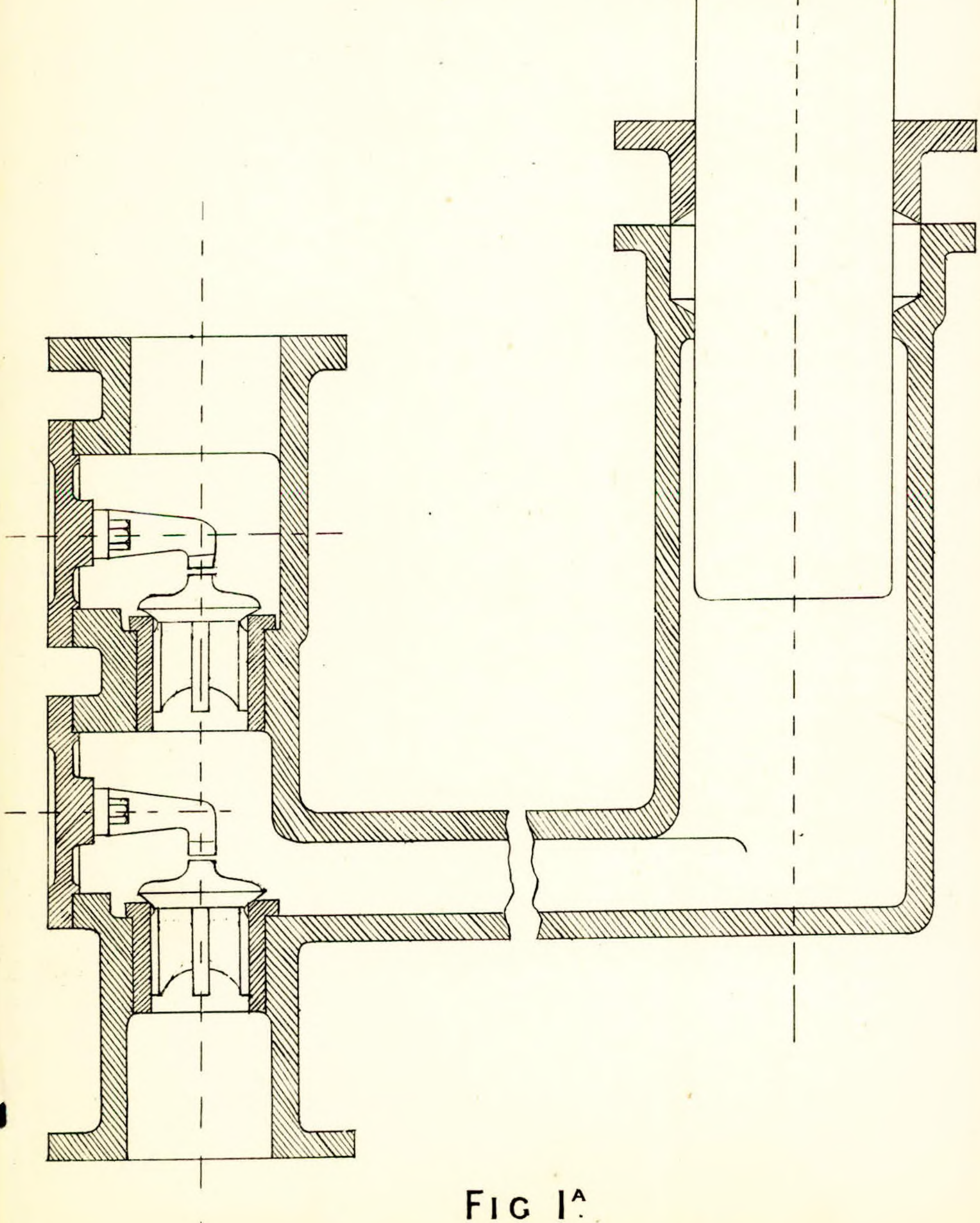


FIG 1A.

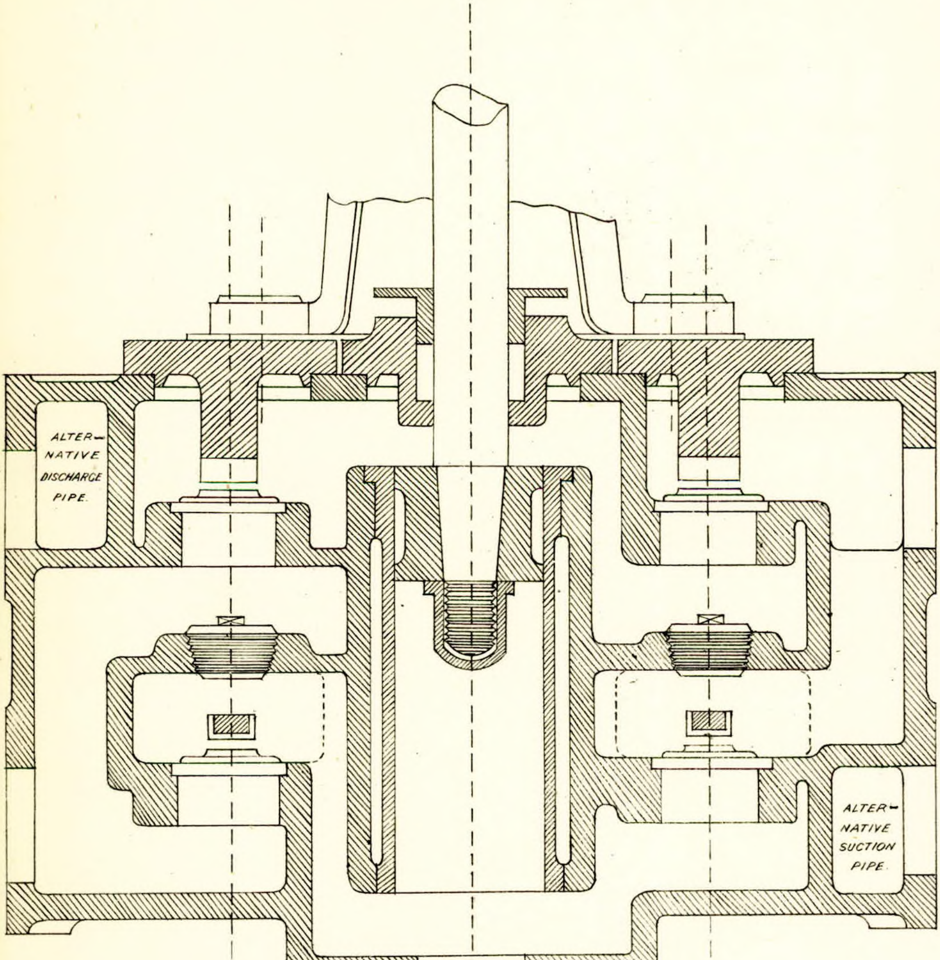
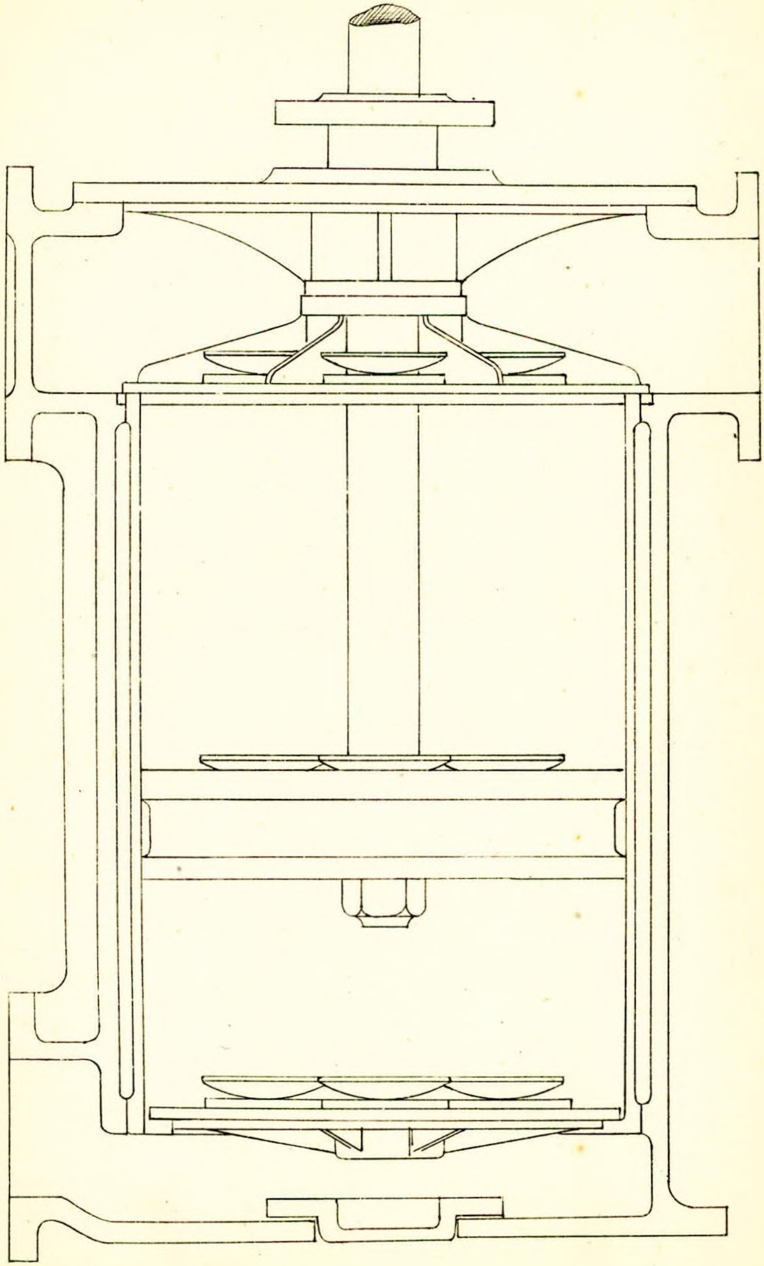
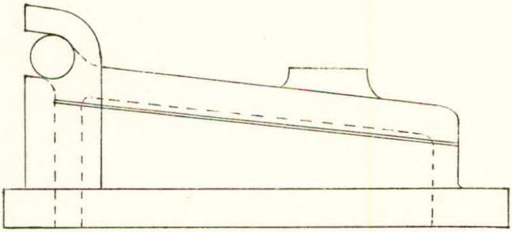


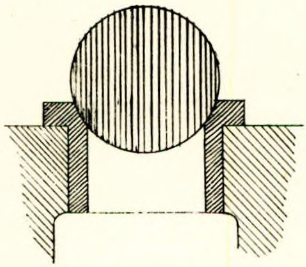
FIG 2.





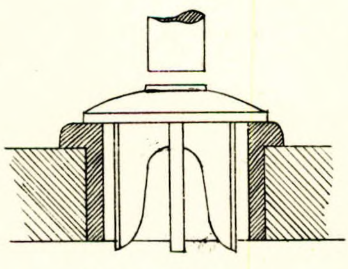
Clack Valve.

B



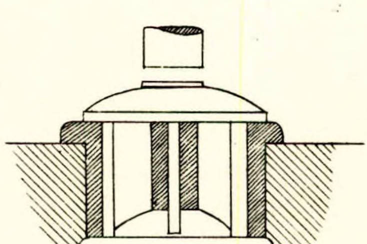
Ball Valve

C



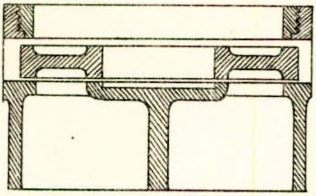
Wing Valve.

D



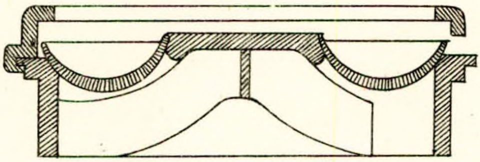
Central Spigot Valve.

F



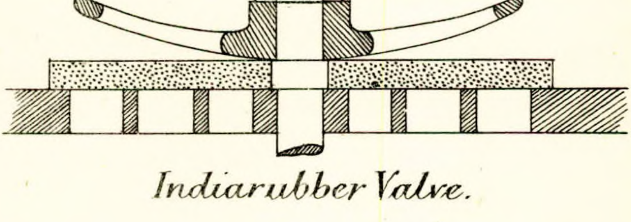
Reid's Valve.

F



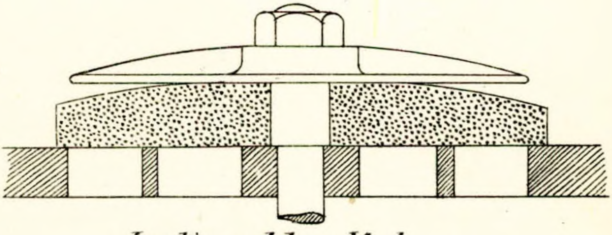
Reid's Valve.

K



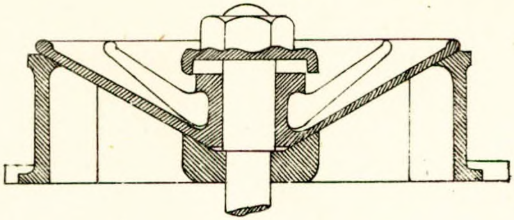
Indiarubber Valve.

L



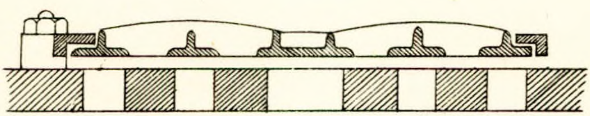
Indiarubber Valve.

I



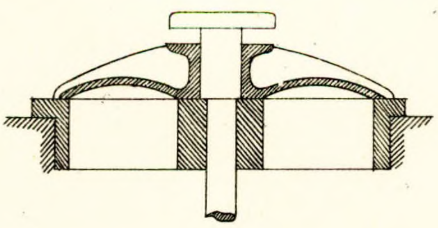
Hawks' (Davey's Improved) Valve

J

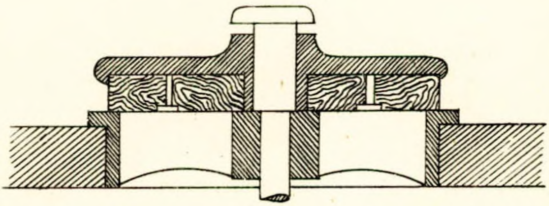


Annular Valve

H

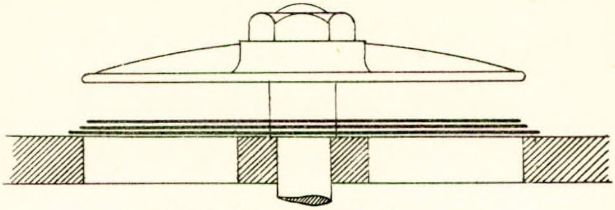


E



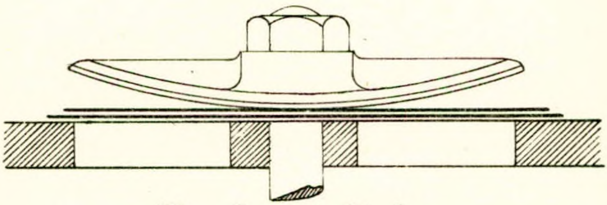
Wooden Valve.

R



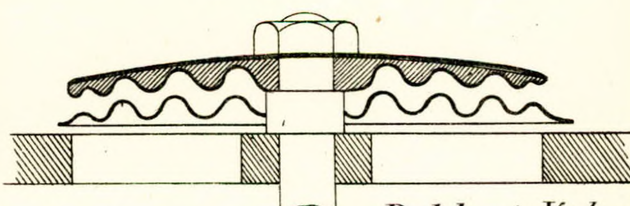
Kinghorn's Valve.

Q



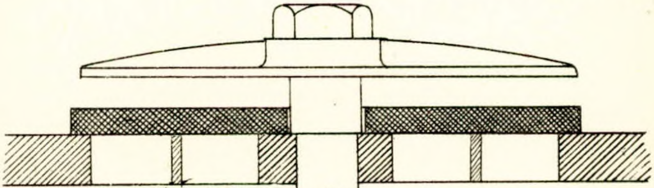
Kinghorn's Valve.

P



Beldam's Valve.

N & O



Fibre Valve.

G