

## ON AN IMPROVED FORM OF SLIDE VALVE FOR STEAM AND HYDRAULIC ENGINES.

---

BY MR. FRANCIS W. WEBB, OF CREWE.

---

For many years past attention has been directed to finding some means whereby the great wear and tear of the Slide Valves and port faces of engines might be lessened. This object the writer thinks he has succeeded in effecting to a great extent by the valve to be described, which has been worked successfully for  $1\frac{1}{2}$  years. It was first brought out by the writer in 1869, but not being at that time connected with locomotive engineering he had not then the opportunity of trying it. The valve differs from the slide valves in ordinary use in being made circular and free to revolve in its buckle; so that if the valve should have a tendency to seize in any one part of the sliding surface, which would put more friction on that particular side, it will immediately begin to revolve, and so rectify itself by bringing different portions of the surfaces to bear. By this means the grooving action is avoided that arises in ordinary rectangular slide valves from their unequal bearing, the sides of the rectangular valve having a continuous bearing that is never out of contact, whilst the ends of the valve travel across the open ports. The valve wears out of level in consequence, and leakage begins almost from the time of starting, and increases until it becomes so bad as to necessitate refacing the valve and the port face, often a troublesome and expensive process. This has been found a serious practical objection in ordinary slide valves, and different means have been tried for reducing it, such as plugging the valve face with white metal, or drilling open holes in the slide flange; but these only partially meet the case.

In this Circular Slide Valve, by its rotation in the buckle, all parts of the face are made to bear alike, and any grooving action is

effectually prevented by the circumstance that an inequality or increased friction at any one part causes the valve at once to shift its position by turning round in the buckle. The result is that no grooving action ever takes place, and the valve retains a perfectly level polished face.

This valve is shown in Figs. 1, 2, and 3, Plate 27, as applied to a locomotive engine with outside cylinders. The valve spindle A is carried in the usual way with a bush and gland at one end, and a bush at the other; it is supported however by the slipper B, as it has also to carry the weight of the valve, the usual ledge for taking the weight off the ordinary rectangular valve not being applicable in this case. The valve C is turned true in the lathe on the face, steam and exhaust port edges, and also where the buckle fits; and this is left sufficiently slack when cold to be quite free when the brass or iron valve is expanded by heat in the wrought-iron buckle. In Fig. 3, the outer curve of the port D is struck with the same radius as the valve over the lap, and the inner curve of the port with the same radius as the exhaust cavity of the valve; so that the ports open simultaneously all the way round the valve, both for lead and for exhaust. This of course can be varied by altering the curved shape of the port, if it is thought desirable to let the lead or exhaust open in the centre first, so as to make it more gradual. The clearances E and F at the top and bottom of the face are so arranged that, during the revolution of the valve in the buckle, every portion of the valve face will pass over them; this also relieves the pressure on the valve to a slight extent without affecting its efficiency, and affords a ready means of getting the valve face fully lubricated. One of the pair of valves shown on the table has now run about 20,090 miles, and the other 4,090 miles; and they have been merely taken out to show their condition, that it may be seen that the faces remain true, though they have not been faced up since first started. These valves are of cast iron, and their condition shows that with this form of valve cast iron can be used for high-pressure engines.

In connection with this particular form of valve, the writer has also arranged a method of taking off the pressure by means of a back

ring working against the steam-chest cover, but this has not yet been put to work; and with the very good surface that can be maintained with this valve, it does not appear to be required, as a very small leakage through the back packing-ring would soon overbalance any saving that may be effected. That method of relieving a rectangular valve was first tried many years ago by Mr. A. Allan, formerly the works manager at Crewe, in the engine "Phalaris" in 1844, and subsequently in the engine "Velocipede," which was built in 1847. Figs. 13 to 15, Plate 30, copied from the original drawing, show how the back packing-ring was applied; and in the opinion of the writer, if the valve-chest cover had been sufficiently strong to avoid warping under the pressure, it would have been quite successful.

In Figs. 4, 5, and 6, Plate 28, is shown the application of the circular slide-valve to an inside-cylinder locomotive.

Another application of the circular valve, which the writer has found extremely useful, shown in Fig. 7, Plate 29, is in the hydraulic capstan engines, where the slide valves have proved a continuous source of trouble through galling, as seen in the two samples shown on the table of the ordinary rectilinear valve out of an Armstrong capstan. But the sample exhibited of the circular valve shows how completely its revolving action rectifies itself; in fact, taking any number of valves from different engines, the surfaces are kept so true and perfect that when only simply wetted one will support the weight of another. It may be mentioned that the circular valves on the table had been working continuously night and day at Camden Station for eighteen months before they were taken out, under a pressure of 700 lb. per sq. in., while the rectangular valves have only worked seven and ten months respectively.

A further application of the same principle of valve is in one of Brotherhood's simple direct-acting three-cylinder capstans. This valve has been at work for some months at the North Western Railway works at Crewe, under a pressure of 350 lb. per sq. in. For this the writer has designed the arrangement shown in Figs. 8 to 12, Plate 29, which has so far proved successful. It consists of a brass disc G, Figs. 11 and 12, grooved concentric on its face to receive three cast-iron pieces I, in each of which a small circular brass valve

J, Fig. 10, is inserted ; the cast-iron pieces are used in order to get sufficient rubbing surface in the groove of the brass disc to avoid cutting. The brass disc is rotated by an eccentric pin H, turned by the capstan crank-shaft, on the opposite side to the one on which the valves are placed. The port face has three radial recesses, in each of which are formed an inlet and outlet port, Fig. 9 ; the valves are of the same diameter as the width of the recesses into which they are placed, and they have a reciprocating motion imparted to them by the eccentric movement of the brass disc. The inlet ports are made in a similar manner to those of the locomotive previously described ; but the outlet port, for a single-acting valve like this, is made circular for the sake of simplicity. A set of these valves has just been taken out, and is shown on the table, that their condition may be seen after being at work a considerable time.

---

Mr. WEBB mentioned that there had been some trouble at first with the slide-valves of the three-cylinder hydraulic capstan which were first designed ; these were rotary three-ported valves of phosphor bronze, working on seatings of the same metal ; but the seatings had since been made with a wood face, and now gave no trouble when working under a pressure of 700 lb. per sq. in. The small slide-valves of the three-ram hydraulic capstans had previously given a great deal of trouble, and he had tried the circular slide-valve in the first instance in an Armstrong capstan ; he had now got nearly every ram-capstan on the London and North Western Railway working with these valves, and they were all in good condition. One of those exhibited had been working night and day for nearly two years, since Sept. 1875, and as could be seen was still in excellent condition. Of the two cast-iron locomotive valves exhibited, one had run 20,090 miles, and had worn down perfectly true, only 1-32nd

inch having been worn off. A brass valve of the same kind, working on the other side of the same engine, wore equally well as regarded keeping a true face, but the metal wore down as fast as the ordinary rectangular brass valves did, the wear amounting to 3-16ths inch in the brass valve after running 16,000 miles. In order to see whether there was any difference in the two port faces, the other cast-iron valve exhibited was then put in the place of the brass valve, and had now run 4,090 miles with scarcely any appreciable wear; and on placing these two valves together, face to face, it was seen that the faces of both had worn perfectly true, and that thus the difficulty of the wear and tear in the ordinary slide-valves had been got over, as well as some considerable portion of the friction.

Mr. J. C. WILSON considered there could be no doubt that this valve was a very good construction for preventing grooving, and for wearing equally well all over; for it was well known that even the fact of rounding the steam ports at the ends with an ordinary square valve had a decidedly beneficial effect. It appeared to him however that with this form of circular slide-valve there must be a greater amount of wire-drawing of the steam, on account of the curved form of the port, than with the square straight-ported slide-valve. Another objection that he noticed was the increased length of the steam ports; the capacity of the ports must be greater with a valve of this kind than with an ordinary slide-valve, the length of the port to the corners of the semi-circle being greater than if the port was taken square across; that would occasion a greater waste of steam at every stroke. Otherwise, in regard to the wear and tear of it, all experience went to prove that it would certainly be a very good valve.

Mr. BENJAMIN WALKER mentioned that in making some experiments about twenty years ago with regard to the use of steam at a pressure of 250 lb., he had found that the slide-valves could not be kept in good condition at all; whatever sort of metal was used, cast iron or brass, the friction was so severe that they were very soon destroyed. A cylindrical piston-valve was then introduced, the body of the valve being made like a common piston with two grooves turned in its

circumference, so as to leave one broad ring in the middle of the piston, and a smaller one beyond it at each end; the steam at the back of the valve pressed it against the port, and it was merely allowed to move freely round on its spindle, and this moving round overcame all the difficulty of friction and grooving, notwithstanding that the full pressure of the steam was on the valve. In the case of some large engines that he had made with these piston-valves the valves had recently been taken out after as much as sixteen years' work, not because they were any the worse for wear, but because the corrosion from the tallow had so destroyed the spindle and arms of the valve that it had become dangerous to work it longer; the face of the valve however was as good as at the beginning. The sliding motion and turning motion taking place at the same time, the valve was constantly kept moving, and there was no possibility of corrosion or grooving of its face. The hydraulic valve shown in the drawings as applied to Brotherhood's three-cylinder capstan was he thought successful: he could not imagine any happier idea than allowing the valve to turn round; it overcame the difficulty of grooving, and was well adapted to keep the circular valve perfectly true. If that plan were applied to a valve to be worked by hand, he thought there would be more total pressure upon it than upon the ordinary rectangular valve, and that some difficulty would arise to the man working it; when the seat was made of gunmetal, and the valve as small as possible, it would be much more easy for the man to handle it. For example, in moving the Bessemer converters backwards and forwards there would be an increased surface of the valve exposed to the pressure, causing greater friction, and it would give the man increased labour, and less facility for handling the cranes with exactness and ease. He was sure Mr. Webb had done mechanical engineers great service by this contrivance, and he had no doubt that it would be adopted extensively.

Mr. P. G. B. WESTMACOTT observed that there seemed to be very excellent results from this circular slide-valve; but although the ordinary rectangular slide-valve had in some cases given a great deal of trouble, there were instances in which it had worked well for a

great length of time. For instance, at the Birkenhead corn warehouses there were twenty-eight hydraulic engines, many of which had now been at work night and day for about nine years under a pressure of 800 lb. per sq. in., and out of the whole lot of slide-valves there were only two that had required to be replaced. There were also slide-valves that had been put in hydraulic engines at the Allenheads lead mines in Northumberland about twenty-seven years ago, which were still working and had never been replaced. It was difficult to account for the difference in the working of valves in one place and in another. The capstan engine had this disadvantage, that being generally an underground machine it received most of the dirt that gravitated to the bottom of the pipes. He should be glad to know what was the mixture of metal that had been used in the circular valves replacing the rectangular valves in the hydraulic capstan at Camden station. The valve that in his experience gave least trouble was the mitre valve. Some mitre valves had been working a long time, about ten years, under a pressure of 800 lb. per sq. in., and had never been touched. The valve that they were chiefly using now at Elswick was the trunnion valve. It gave very good results; he attributed this a good deal to the fact that the distance through which the valve had to travel was small; the port was  $\frac{3}{8}$  in. long, so that in every revolution of the engine the valve travelled through a distance of  $\frac{3}{4}$  in. After three years' very hard work, night and day, some of these valves were only reduced 0.02 inch in diameter. One advantage of the trunnion valve was its great simplicity; it had no levers and no pins, and the travel was small.

Mr. WEBB replied, respecting the metal used for the circular valves of hydraulic capstans that had been referred to, that it was a specially hard mixture composed of 4 parts tin and 16 parts copper.

The PRESIDENT enquired whether Mr. Westmacott had any experience in the use of phosphor bronze for the valves.

Mr. P. G. B. WESTMACOTT replied that he had tried it, but found it did not wear so well as a hard mixture of gunmetal.

Mr. J. PLATT said he had had some experience of a circular slide-valve under hydraulic pressure, shown in Figs. 16 and 17, Plate 30, but the result had not been at all satisfactory. Thinking that the stroke alone was not sufficient to cause the valve to revolve, he had given it a positive turning motion, rotating it by a ratchet wheel on the back of the valve rotated by pauls fixed in the valve-chest, so that the reciprocating movement of the valve gave it also a rotating movement. That plan kept the face perfectly smooth, but he could not get the valve to keep tight. Whether there was something in the twisting motion that relieved the pressure on the face, he could not determine; certainly it had not been at all satisfactory. It was a brass valve  $2\frac{1}{8}$  in. diameter with a 1 in. hole through the centre, and was partly balanced, the pressure being excluded from the back by means of a relieving ring of the full diameter of the valve face, with a leather packing ring arranged to give one-third the area for pressure on the face. He had tried plugging the centre hole, to make it like an ordinary slide-valve, but it was still not tight; then the rotating motion was taken off, and it was found to be tight. Without the relieving ring the valve was tight, but with 1500 lb. pressure it soon began to cut, and it cut more on one side than on the other, and although free to rotate it did not rotate; it scratched the face in a manner that showed there was no rotation, although the conditions were favourable for its rotating. He did not understand how the circular slide-valves described in the paper got a rotating motion, as he could not see how an ordinary slide-valve would rotate without a positive rotary motion being communicated to it.

Mr. E. A. COWPER thought that with the brass valve of the dimensions just given there had probably not been sufficient area of bearing surface under the high pressure employed, and that the metal had seized naturally; the pressure of 1500 lb. per sq. in. was so high that no brass would stand it without seizing. On the other hand, if the pressure was taken entirely off the valve by the relieving ring at the back, it appeared to him that there would be no pressure on the valve to keep it up to the face, and the lever actuating the valve took its bearing against the valve rather high up from the face,



so that there was a tendency in the valve to tip, which would account for its not keeping tight when balanced.

Mr. F. C. KELSON observed that with the circular slide-valve described in the paper it appeared to him the exhaust port would not open to the same extent as the steam port, but less; and he should be glad to know whether that was found to affect the working of the engine.

Mr. WEBB said that, with regard to wire-drawing, there was no more wire-drawing with the circular slide-valve than with the ordinary rectangular valve: the outer curve of the port being struck with the same radius as the valve over the lap, the port opened simultaneously all round from end to end; and the same was the case in opening for the exhaust, the inner curve of the port being struck with the same radius as the exhaust cavity of the valve; the rate of opening of the circular slide-valve was precisely the same as with an ordinary valve having the same lead and travel. With regard to the comparative contents of the port, it would be seen from the drawings that the port was not any longer with the circular valve, but really slightly shortened. As to the revolving of the circular slide-valve, the moment that there was a little more friction on one side than on the other, the valve started and began to revolve.

The PRESIDENT moved a vote of thanks to Mr. Webb for his paper, which was passed.

---

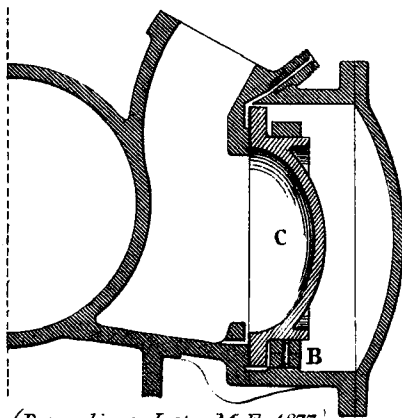
The following paper was then read:—

# CIRCULAR SLIDE-VALVE

Plate 27.

*Application  
to  
Outside-Cylinder  
Express Passenger Engine.*

Fig. 1. Transverse Section.



(Proceedings Inst. M.E. 1877.)

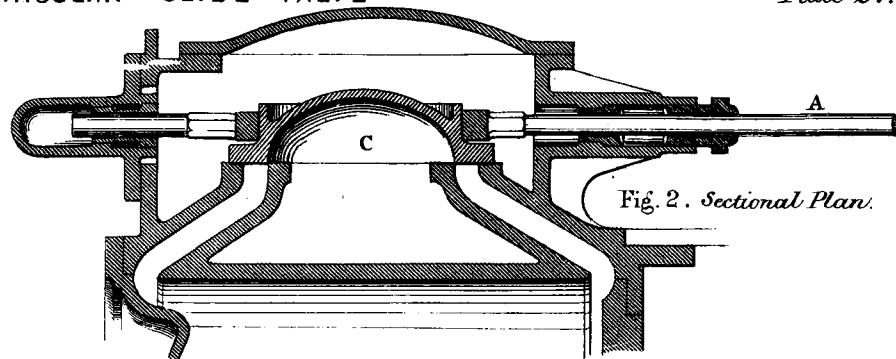


Fig. 2. Sectional Plan.

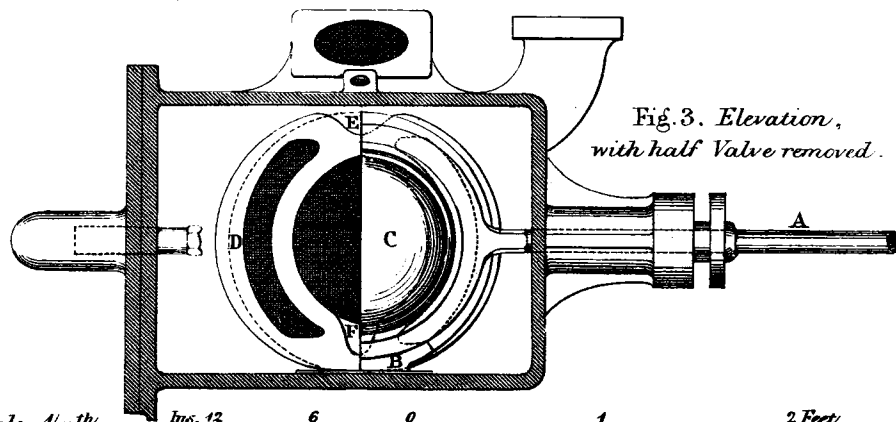


Fig. 3. Elevation,  
with half Valve removed.

Scale  $\frac{1}{12}^{th}$

Ins. 12 6 0 1 2 Feet

Plate 27.

# CIRCULAR SLIDE-VALVE .

Plate 28.

*Application  
to  
Inside - Cylinder Locomotive.*

Fig. 5 .  
*Sectional Plan.*

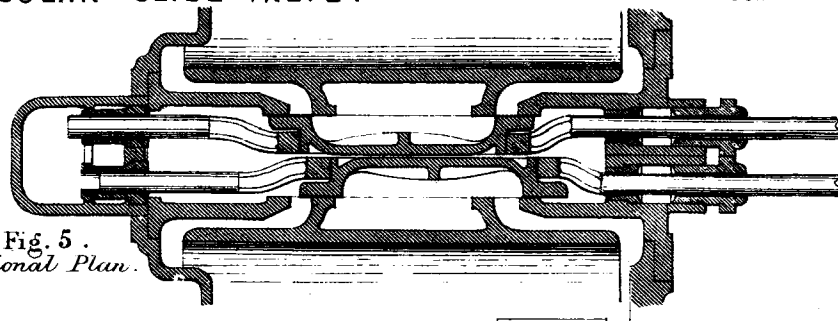
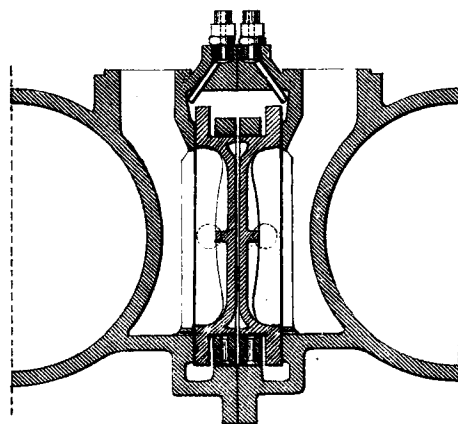


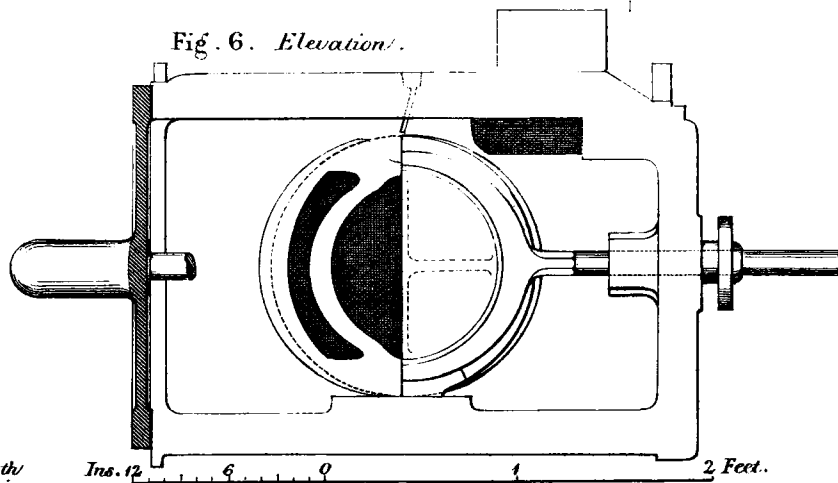
Fig. 4. *Transverse Section.*



(Proceedings Inst. M. E. 1877.)

Scale  $\frac{1}{12}$ th

Fig. 6. *Elevation.*



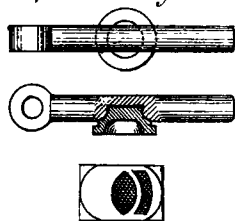
Ins. 12 6 0 1 2 Feet.

Plate 28.

# CIRCULAR SLIDE-VALVE.

Plate 29.

Fig. 7. Slide-Valve for Armstrong Hydraulic Capstan Engine.



Application to Three-Cylinder Hydraulic Capstan Engine.

Fig. 8.

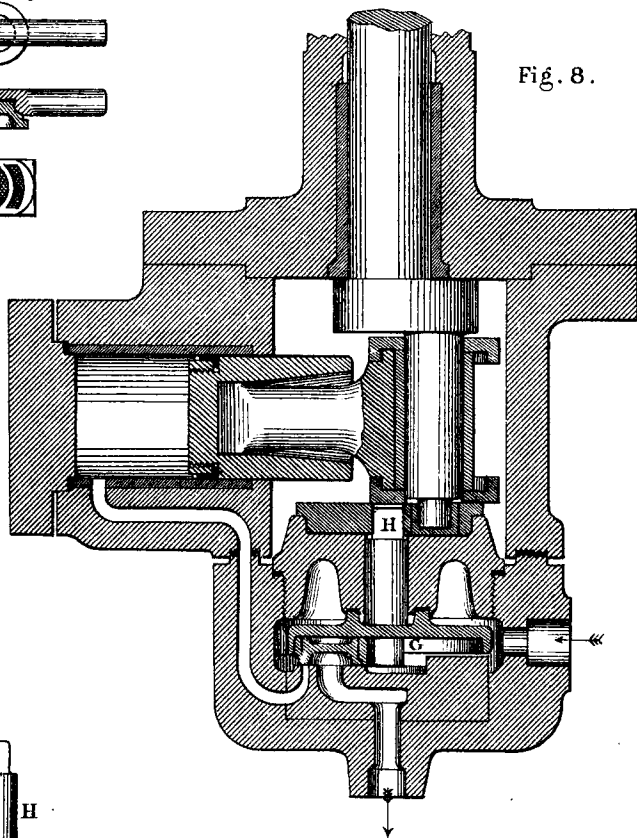


Fig. 10. Valve.



Fig. 11.



Fig. 12.

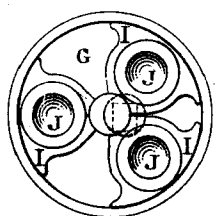
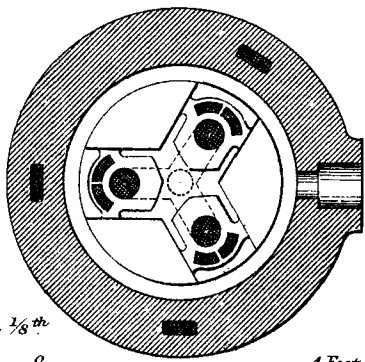


Fig. 9.



(Proceedings Inst. M.E. 1877.) Scale  $\frac{1}{8}^{\text{th}}$

Ins. 12 6 0 1 Foot.

*Allan's Balanced Slide-Valve for Passenger Locomotive.*

Fig. 13.

*Crowe 1844.*

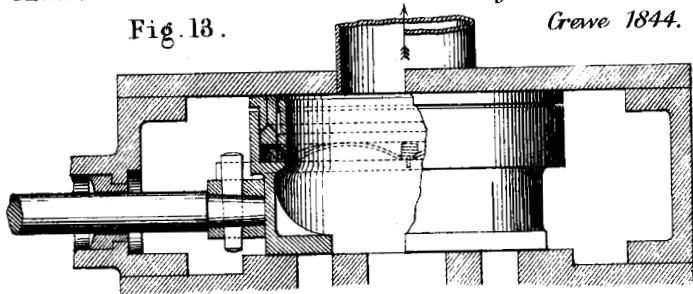


Fig. 14. *Plan.*

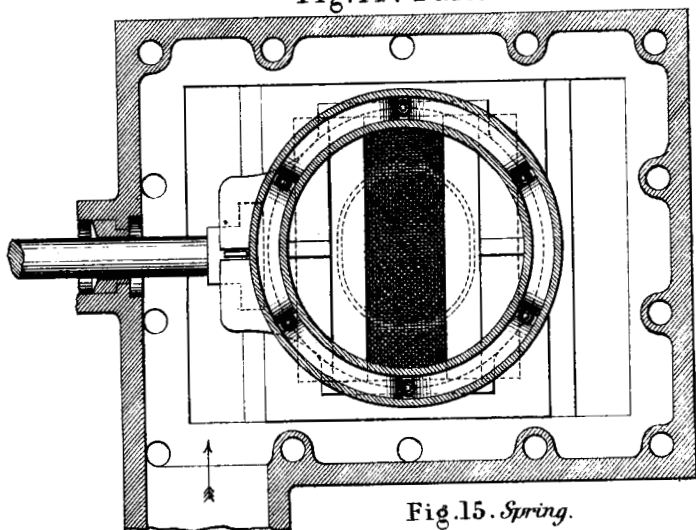


Fig. 15. *Spring.*



*Balanced Circular Slide-Valve  
for  
Hydraulic Pressure.*

Fig. 16.

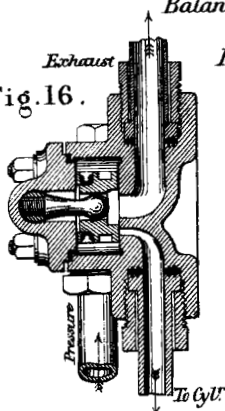
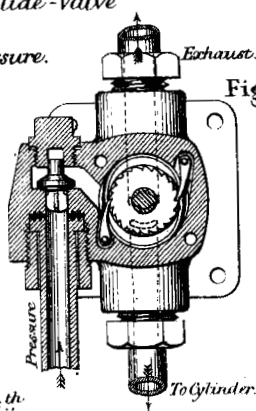


Fig. 17.



Scale  $\frac{1}{6}$  in.

