4 Sheets--Sheet 1.

W. C. CHURCH.

Balanced-Valves.

No. 166,848. Patented Aug. 17, 1875.

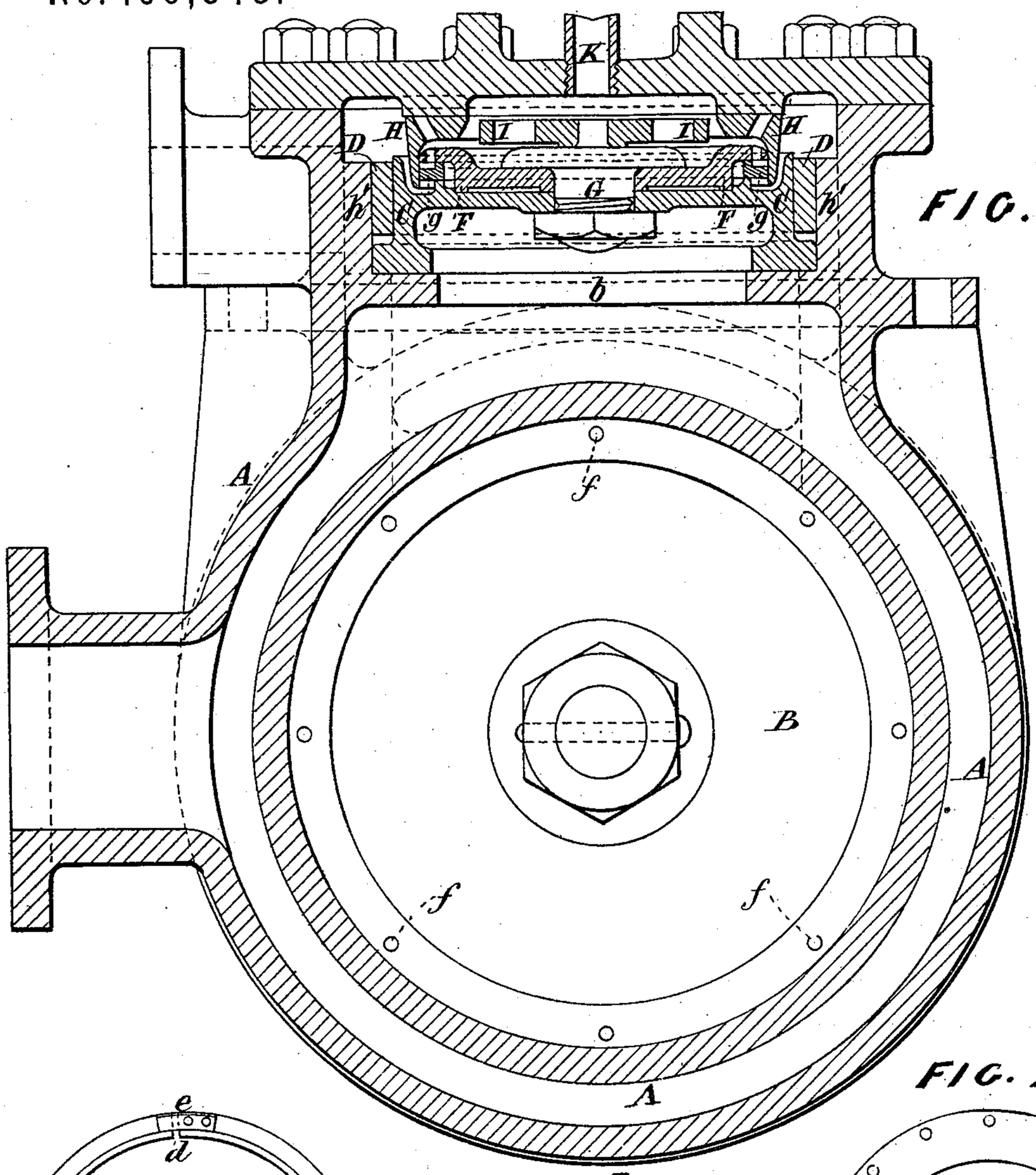
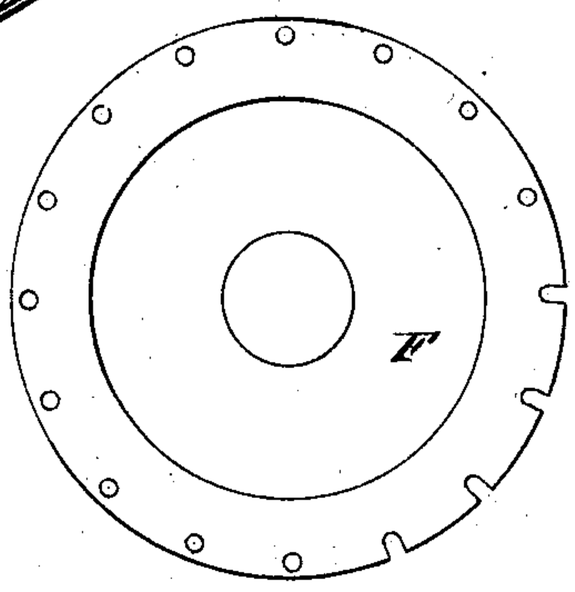


FIG. 1.

FIG. 7.



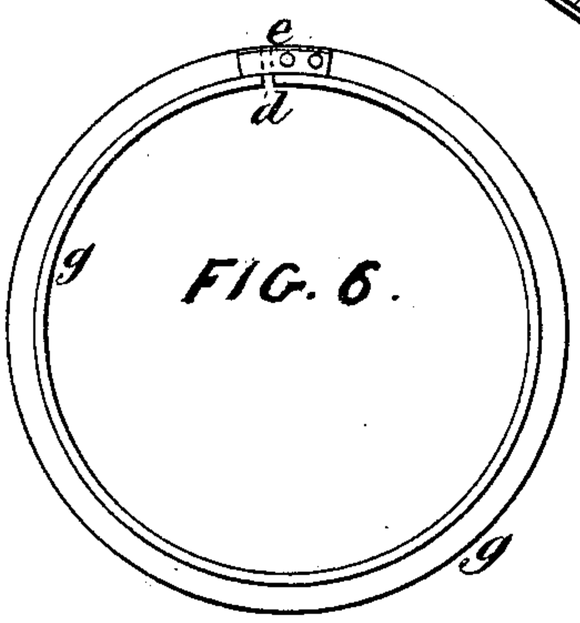
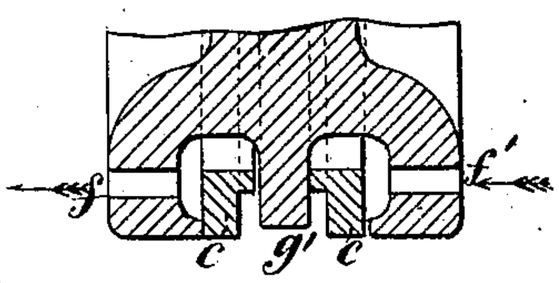


FIG. 6.

FIG. 5



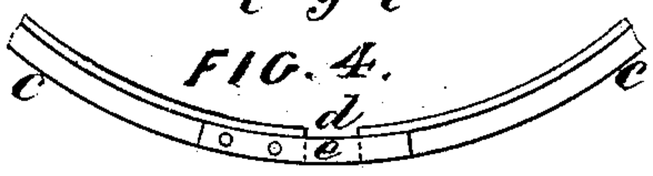


FIG. 4.

Witnesses, Harry Smith
Thomas McElwain

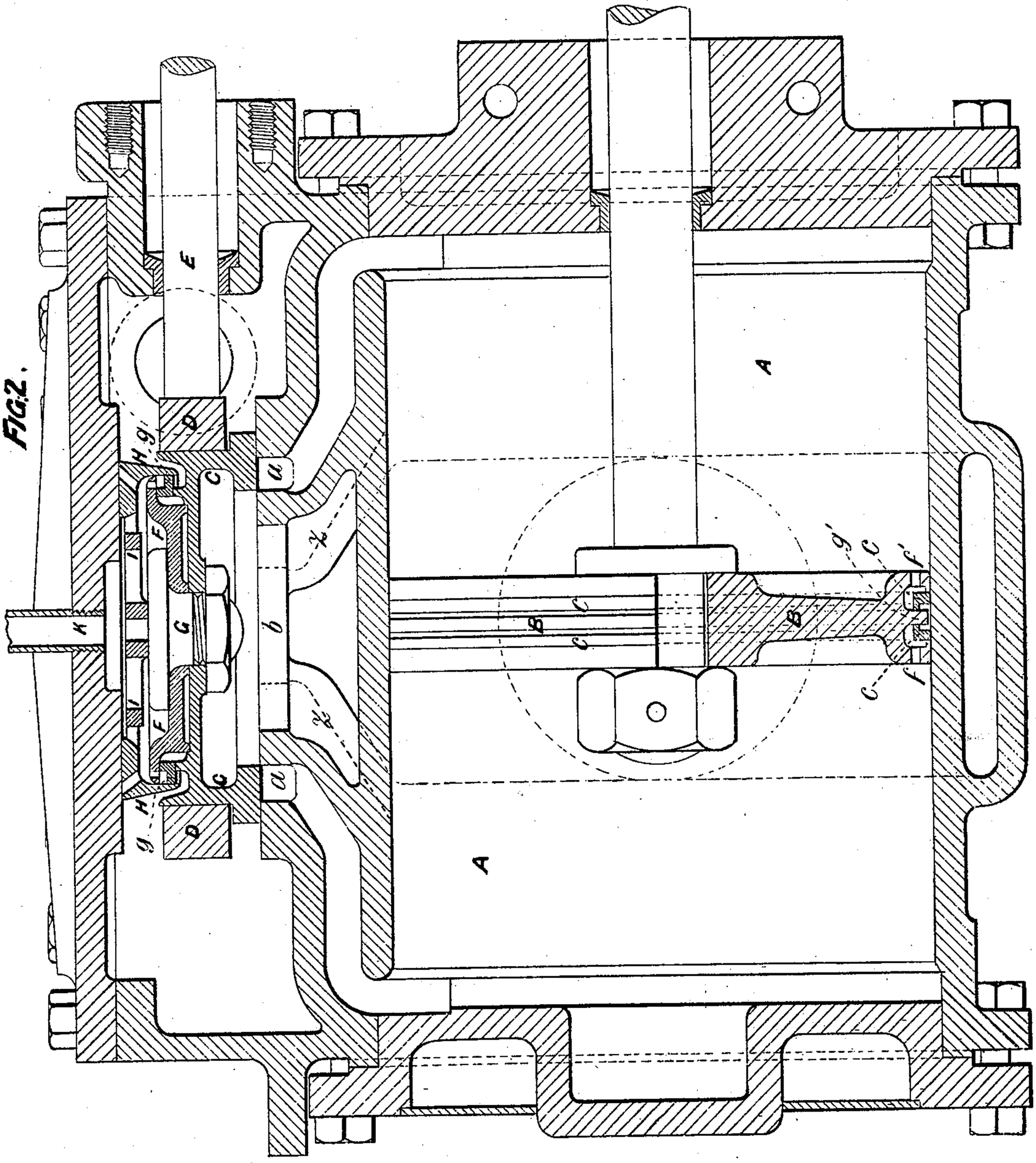
Walter C. Church
by his Attys.
Howson and Son.

4 Sheets--Sheet 2.

W. C. CHURCH.
Balanced-Valves.

No. 166,848. Patented Aug. 17, 1875.

FIG. 2.



Witnesses, Harry Smith
Thomas H. Hall.

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Howson and Son.

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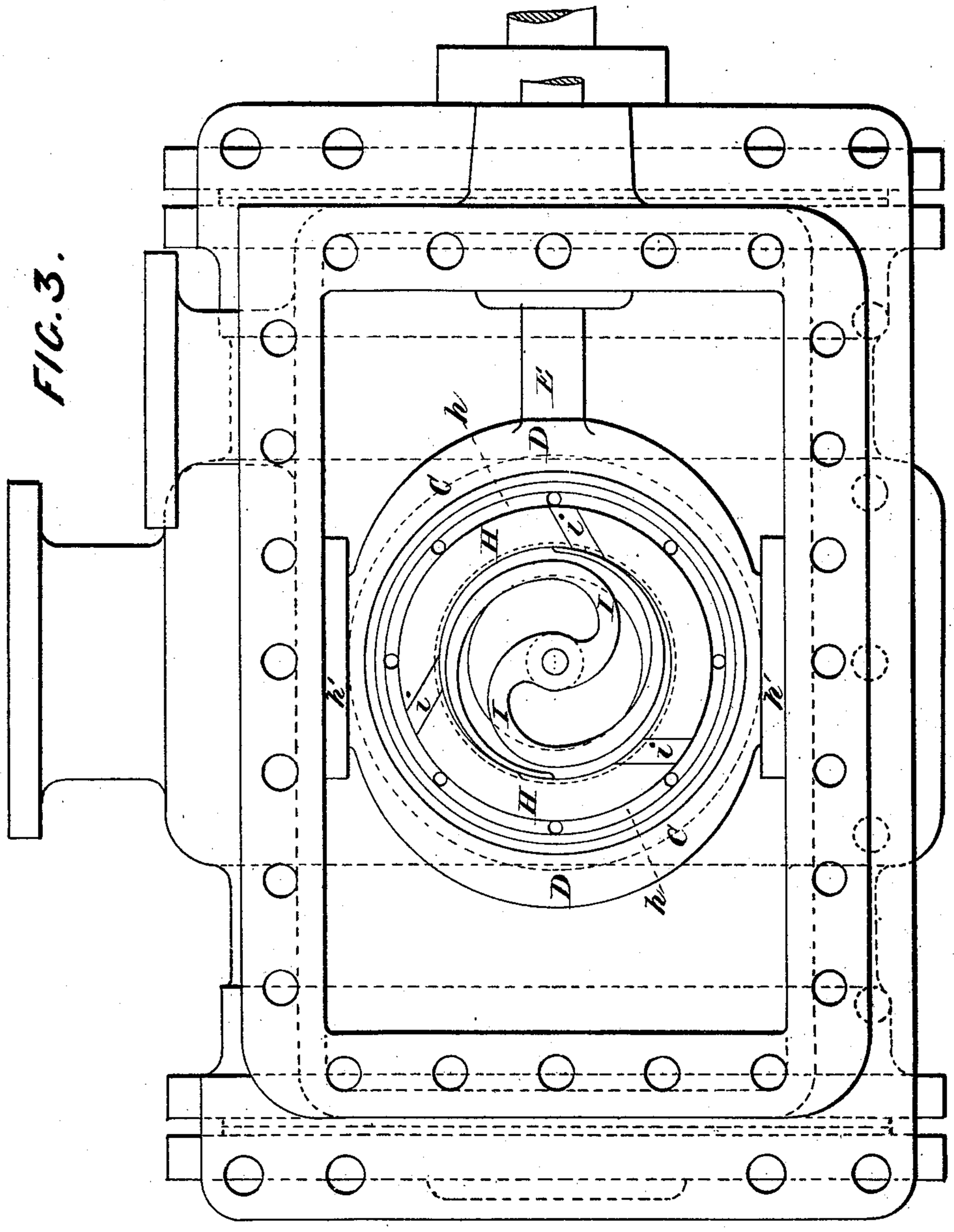
No. 166,848. Patented Aug. 17, 1875.

FIG. 3.



Witnesses. Harry Smith
Thomas M. Elwain

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by his Attys.
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4 Sheets--Sheet 4.

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Balanced-Valves.

No. 166,848. Patented Aug. 17, 1875.

FIG. 9.

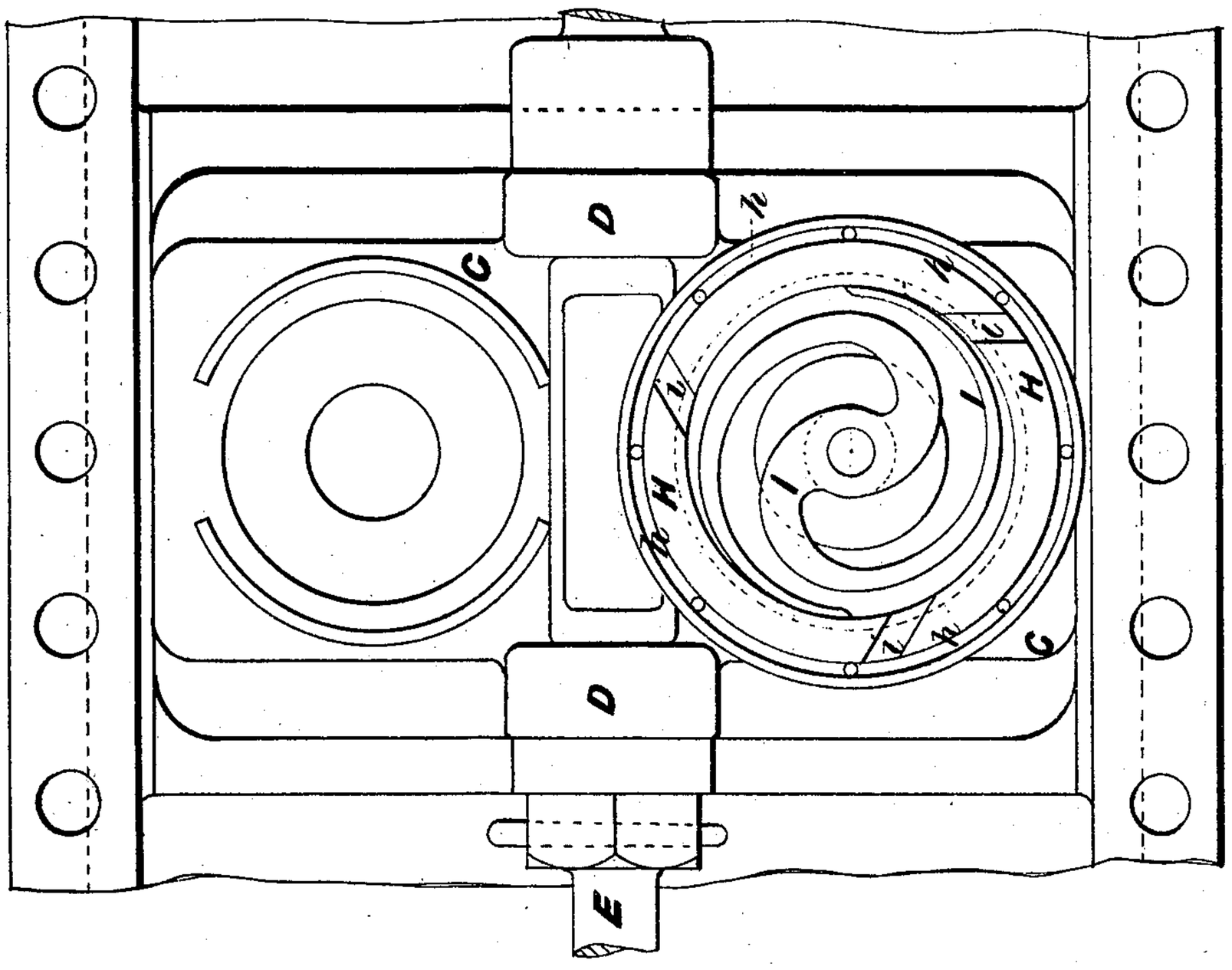
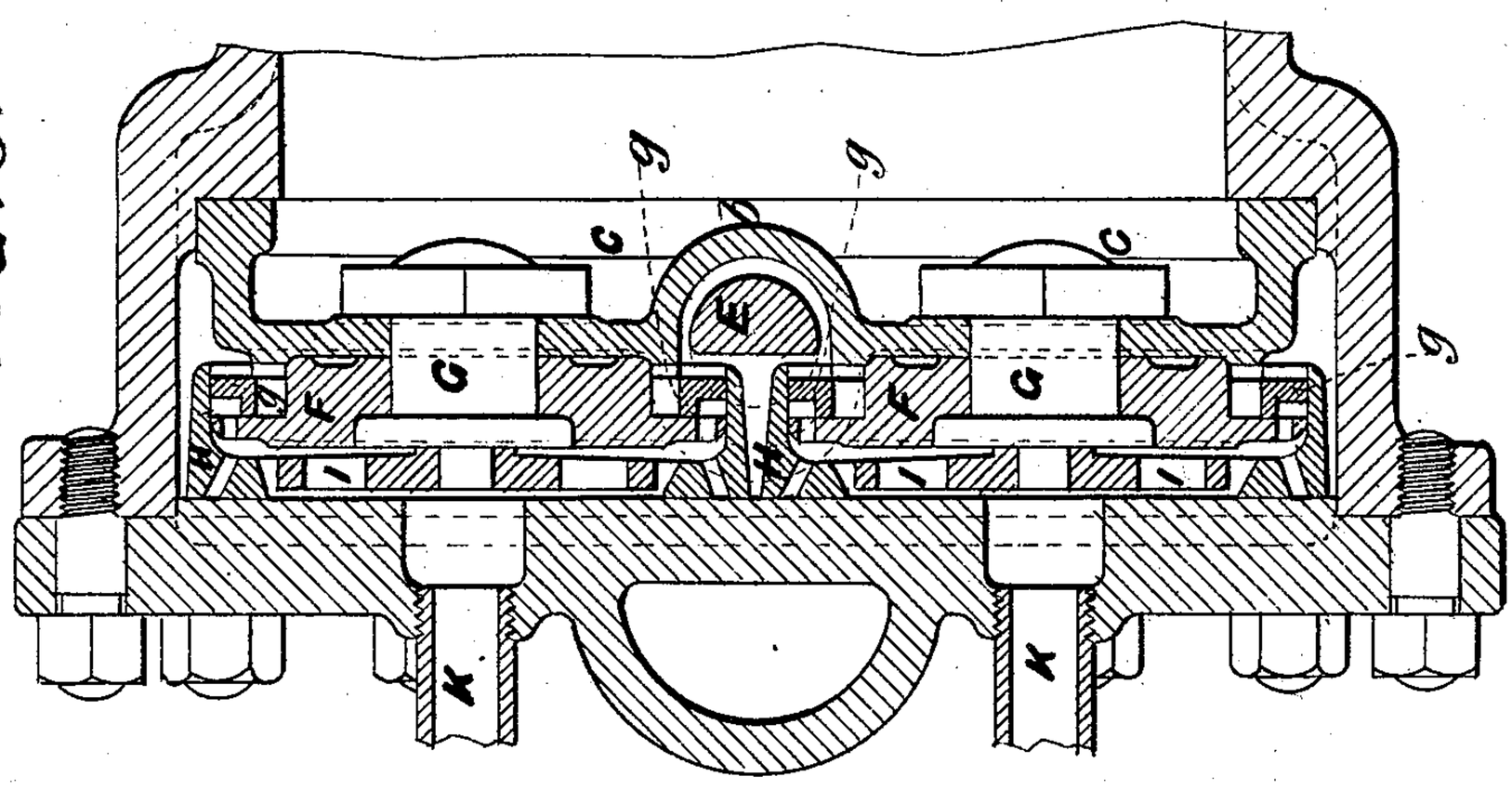


FIG. 8.



Witnesses, Harry Smith
Thomas McEloani

Walter C. Church
by his Attys
Norris and Son

UNITED STATES PATENT OFFICE.

WALTER CHARLES CHURCH, OF LONDON, ENGLAND.

IMPROVEMENT IN BALANCED VALVES.

Specification forming part of Letters Patent No. **166,848**, dated August 17, 1875; application filed March 2, 1874.

To all whom it may concern:

Be it known that I, WALTER CHARLES CHURCH, of 39 Lombard street, in the city of London and Kingdom of England, engineer, have invented Improvements in Steam-Engines, (parts of which improvements are applicable to hydraulic rams and pumps,) of which the following is a specification:

The object of my invention (for which a British patent, No. 563, was issued on the 19th day of April, 1872) is a slide-valve for steam-engines, constructed as described hereafter, so as to prevent undue friction, unequal wear, and the waste of steam.

I propose, according to my invention, to employ a peculiar construction and arrangement of equilibrium slide-valve for steam-engines, such valve being of a circular in lieu of the ordinary rectangular form, and capable of rotating within a circular buckle or clip, such as is hereinafter described, when running with or without steam.

The peculiar construction of slide-valve hereinafter described admits of the removal or balancing of the pressure on the valve more effectually and easily than when an ordinary rectangular-shaped valve is used. I propose to balance or remove the pressure acting on the back of the valve by the employment of a cap or ring of smaller diameter than the valve itself, fitting over a junk-ring secured by a central bolt to the back of the valve—an **L**-shaped packing-ring, which is equally applicable to pistons of steam-engines, rams of hydraulic presses, pistons and plungers of pumps, and to other similar purposes, being interposed between the under side of a projecting flange on the upper surface of the said junk-ring and the body of the slide-valve, and pressed against the inner parallel bored surface of the cap and against the junk-ring by the pressure of the steam in the valve-chest, thus making the said surfaces in contact steam-tight. The cap is kept pressed against the steam-chest cover, when the steam is out, by an **S**-shaped spring fitted onto a central stud, the contact-surfaces of the spring and the cap being beveled or inclined. The junk-ring has a number of holes or radial slots made round its outer circumference, to allow of the escape of any steam which may leak past the contact-surfaces of the metallic packing-ring. The pressure of the steam, when in the valve-chest, against the annular area of the cap next the valve keeps the said cap firmly against the steam-chest cover, and thus reduces the area subject to pressure on the back of the valve. The same arrangement of the cap, junk-ring, **S**-shaped spring, and metallic packing-ring, used either singly or in duplicate, may be applied to a rectangular slide-valve. The said metallic packing-ring is cut through on one side, and is disposed so that the surface in actual contact with the internal bored parallel surface of the cap shall have a less area than the inside annular area of the said packing-ring, which is subjected to the direct pressure of the steam admitted behind the ring, whereby I obtain an excess of expanding force tending to press the packing-ring outward against the internal bored parallel surface of the cap over that which tends to press it inward, and hence I prevent leakage. In conjunction with this action the steam also exerts a pressure which forces the reduced annular area of the packing-ring against the under or inner side of the projecting flange of the junk-ring. A segmental joint-piece, such as is hereinafter described, is to be placed across the joint in the packing-ring, in order to make good the joint and prevent leakage through the same.

And in order that my said invention may be fully understood, I shall now proceed more particularly to describe the same, and for that purpose shall refer to the several figures on the annexed six sheets of drawings, the same letters of reference indicating corresponding parts in all the corresponding figures.

Figure 1 of my drawings represents a transverse section of a sixteen-inch locomotive-engine cylinder with my improved slide-valve. Fig. 2 is a longitudinal vertical section of the same. Fig. 3 is a view of the back of the improved slide-valve, the cover of the valve-chest being removed; Figs. 4 to 7, detached views of parts of the valve.

A is the cylinder, which, with the exception of the steam and exhaust ports *a a* and *b*, and steam-passages, as hereinafter described, may be of the ordinary construction. C is my improved circular equilibrium slide-valve, which is of peculiar construction. It is left free to

revolve during its travel within the clip or buckle D on the valve rod or spindle E, by which arrangement the relative surfaces of the valve and port faces are continually varying, thereby preventing the formation of grooves, and consequently producing a greater uniformity of wear and a longer duration of both valve and port faces, whether worked as an equilibrium or as an ordinary valve. The circular slide-valve may be economically made by turning it up and facing it. In the lathe F is a junk-ring, (shown in detail plan in Fig. 7,) which is also turned in a lathe. This ring is fixed onto the back of the valve by a central bolt and nut, G. Above and around this junk-ring there is adjusted the loose cap H, also turned up and faced in the lathe, which cap slides against the face of the steam-chest cover, thereby preventing the pressure of steam or other fluids from acting on the area contained in the inside diameter of the cap H, in contact with the metallic packing-ring *g*.

A steam-tight metallic packing-ring is established between the junk-ring and the top of the valve and the inner parallel bored surface of the cap H by the interposition of the L-shaped packing-ring *g*, (shown in detail plan in Fig. 6,) the said ring being forced outward, and at the same time forced against the under or inner side of the projecting flange of the junk-ring, so as to maintain a tight joint and prevent leakage of steam by the pressure of the steam in the valve-chest. When the steam is out of the valve-chest the cap H is held in contact with the steam chest cover by the S-shaped spring I, (shown in section in Figs. 1 and 2, and in plan in Fig. 3,) which spring is placed centrally on a stud or tap turned on the end of the bolt G, while the extremities of its two arms, which are beveled or inclined, so as to fit the inner beveled or inclined surface of the cap, are made to press against such beveled or inclined surface, and, consequently, the horizontal and vertical tension of the spring forces upward the said cap. The said S-shaped spring can be cast either in gun-metal, iron, or steel, or forged out of ordinary spring-steel, as may be required, and is made larger in diameter across the arms than the internal diameter of the beveled or inclined surface of the cap, as required. The action of the spring is so designed that in case one of the arms should accidentally break, the remaining arm still retains its elastic action both horizontally and vertically, as, the spring being bored out centrally to fit on the stud or tap turned on the end of the bolt G, it forms a kind of fulcrum for the action of each arm, so that one can work independently of the other. I have found it necessary in practice to make the metal of the metallic packing ring or rings *g* of the valve much softer than either that of the cap H or junk-ring F—that is to say, if the cap H and the junk-ring F are made of gun-metal, the metallic packing-ring *g* should be made of soft brass, so as to prevent the outer surface of the metallic packing-ring *g* from wearing or forming grooves in the internal parallel bored surface of the cap H, as well as in the surface of the projecting flange of the junk-ring F, by reason of the extension and compression of the rings while working. In the center of the steam-chest cover a pipe, K, is fitted, leading into the atmosphere, such pipe forming the vent for any steam that may escape between the cap H and the valve-chest cover, or may leak past the packing-ring *g*. A number of holes or radial slots are made round the edge of the junk-ring, as shown in Fig. 7, to allow of the free escape of any steam that may momentarily leak past the surfaces of the metallic packing-ring when the steam first enters the valve-chest, and other openings are made through the cap H, such openings communicating with an annular groove or channel, *h*, Fig. 3, made in the sliding face of the cap, which groove or channel, in conjunction with other channels or sunk parts at *i i*, also serves as a free vent for any steam that may leak behind the cap H when first put to work on the engine.

It will be seen, by referring to the plan, Fig. 3, that the clip or buckle D, surrounding the circular slide-valve C, is bored out, so as to be an easy fit over the back part of the valve, to allow the valve to rotate freely within it. The semicircular ends of the buckle D are struck with the same radius as the diameter of the valve-face C, each being struck from a separate center, for the purpose of giving a greater sectional area on the longitudinal center line, the section of which is shown in the longitudinal section, Fig. 2, so as to keep the buckle D from springing, and thereby allow the valve C to rotate freely within the buckle D during the reciprocal motion of the valve. A flat surface is provided on each side the total depth of the buckle D, so as to form a guide between the projecting surface *h'* on each side of the steam-chest, to keep the valve C always central over the ports, and thus prevent any lateral motion of the buckle D by the rotation of the valve C. These projecting surfaces *h' h'* are suitably faced on the inner side, and also serve to impart a rotary motion to the slide-valve when traveling without steam, by reason of the periphery of the face of the valve rolling against one or other of the said surfaces. The same rotatory motion of the valve C is also obtained when under steam, if one side of the valve-face or port-face should become dry for want of more lubrication than the other side, as a greater amount of friction will be caused on that part of the port-face or valve-face through a deficiency of lubrication, thereby creating a greater amount of cohesion between the parts in contact, and by the reciprocal motion of the valve C this excess of cohesion on one side of the valve-face over the other will cause the valve C to rotate in its buckle D, thereby causing a uniformity of wear between the surfaces in contact.

The following proportions of the acting surfaces of the metallic packing-ring *g* for a twelve-inch circular slide-valve constructed according to my invention will be found to answer well in practice: The outer reduced annular area of the metallic packing-ring *g* in contact with the internal parallel surface of the cap H is about nine square inches, and the inner area of the metallic ring exposed to the pressure of steam in the steam-chest is about thirteen square inches, showing an excess of about four square inches for forcing the outer reduced annular area against the internal parallel bored surface of the cap H by the pressure of steam in the steam-chest. The reduced annular area of the metallic packing-ring *g* on the upper side, next the junk-ring F, is about six square inches, and the area of the lower side of the ring, next the valve exposed to the pressure of steam in the steam-chest, is about seventeen square inches, showing an excess of about ten square inches for forcing the upper reduced surface of the ring against the projecting flange of the junk-ring F by the pressure of steam in the steam-chest.

By these means I insure a perfectly tight contact, and thus prevent any escape of steam or other fluids past the said surfaces when working. The proportions will vary, and consequently the areas, according to the width, depth, and diameter of ring or rings adopted.

Fig. 8 of my drawings represents a transverse vertical section of an ordinary rectangular slide-valve, the back pressure on which is avoided or reduced by the application thereto of my improvements, consisting of the junk-ring, cap, S-shaped spring, and metallic packing-ring, acting as hereinafter described. Fig. 9 is a corresponding plan or view of the back of the slide-valve with the valve-chest cover removed, showing a duplicate arrangement of caps, one cap being in its working position, and the other cap removed. In cases where the rectangular slide-valve is nearly square, a single arrangement of cap, junk-ring, packing-ring, and S-shaped spring may be used. C is the rectangular slide-valve, which is connected to the valve-rod E by eyes D D, formed on the back of the valve, through which eyes the rod E is passed, and is secured therein by a nut at one end, and a loose collar at the other, as shown in plan in Fig. 9.

It will be seen that the valve-spindle E is flattened on the top side in the center part of the valve, as shown in section in Fig. 8, and in plan, Fig. 9, for the purpose of allowing the caps to be placed closer together, and thereby obtaining a greater area for displacement of steam on the back of the rectangular valve, due to the inside diameter of the caps H, or, more strictly speaking, the line of contact between the outer diameter of each metallic packing-ring *g* and the internal diameter of its cap H. A pair of junk-rings, F F, are secured by means of the bolts G G to the back of the valve, and in combination with each junk-ring there is provided a cap, H, and S-shaped spring I, and a metallic packing-ring, *g*, all arranged and operating precisely as and for the purpose hereinbefore described in reference to the circular slide-valve. K K are the two vent-pipes, one for each junk-ring and cap, one of which I have also previously referred to.

When either the circular or the rectangular slide-valve is under steam, the steam in the steam-chest presses upon that part of the annular area of the cap or caps H next the valve, which area is due to the difference of its inner and outer diameters; and as this annular area is greater than that on the top of the cap or caps H, which is outside the annular channel or groove *h h*, Figs. 3 and 9, the steam consequently forces the cap or caps H tight against the steam-chest cover, and by the position and formation of the annular groove *h h* any steam-pressure from small leakage, caused by the surfaces not accurately fitting one another when first put to work on the engine, is prevented from being realized on the additional wearing-surfaces on the cap-face pressed against the steam-chest cover, and contained within the annular channel or groove *h*, since such leakage will pass off by the channels *i* to the vent pipe or pipes K. The surfaces of the cap or caps H and steam-chest cover, after working for a short time, will become perfectly tight.

Should the spring I not force the surface of the cap-face tight against the surface of the steam-chest cover when the steam is shut off from the steam-chest, the moment the steam is readmitted into the steam-chest the pressure of steam, acting upon the annular area of the said cap or caps next the valve, instantly forces the cap or caps against the steam-chest cover by reason of the annular area of the cap or caps next the valve being greater than the annular area on the cap-face pressed against the steam-chest cover, which is outside the annular groove *h h*. All leakage is carried off by the annular groove *h h* and sunk parts *i i*, and escapes through the pipe or pipes K into the atmosphere, as shown on the drawings, Figs. 2 and 8, there being always a free communication through the pipe or pipes K to the atmosphere when the valve C is working as an equilibrium slide-valve, thereby gaining the remaining area or areas contained within the groove *h* or passages *i* on the cap-face H for additional wearing-surface, and diminishing the friction and pressure per square inch between these surfaces. I thus increase the durability of the cap-face, as the total areas of the cap-face sliding on the steam-chest cover are greater than the annular area of the cap H next the valve, C, exposed to the steam-pressure in the steam-chest.

It will be seen from the drawings that the cap or caps H are kept central by their inner parallel part fitting over the junk ring or rings F, either on the circular or rectangular valves, and are independent and

free to have a rotary motion round the junk ring or rings F when traveling without steam, especially on locomotive-engines, since one side of the S-shaped spring will, in practice, press one side of the cap or caps H against the steam-chest cover with a greater pressure than the other. By this means a greater amount of cohesion is produced between the surfaces in contact, and by the reciprocal motion of the valve C this excess of cohesion on one side of the cap over the other will cause the cap or caps H to rotate around the junk ring or rings F, thereby causing a uniformity of wear between the surfaces of the cap or caps H and the surface of the steam-chest cover. The same rotatory motion of the cap or caps H is obtained when under steam, if one side of the cap or caps in contact with the steam-chest cover should become dry for want of lubrication, as a greater amount of friction is thereby caused on that part of the cap or caps, thus creating a greater amount of cohesion between the parts in contact, and by the reciprocal motion of the valve C this excess of cohesion on one side over the other will cause the cap or caps to rotate round the junk ring or rings F, and insure a greater uniformity of wear between the surfaces in contact. The S-shaped spring, by fitting loosely onto a central stud or tap turned on the head of the bolt G, is left free to rotate with the cap or caps, if required.

By referring to the drawings, Figs. 1, 2, and 8, it will be seen that by the formation of the metallic packing-ring *g* the upper reduced area of the said ring, which is pressed against the under side of the projecting flange of the junk-ring F, is less than the area exposed to steam-pressure on the side next the valve C; also, that the internal area of the packing-ring acted upon by steam-pressure is greater than the reduced external area which is pressed against the internal parallel bored surface of the cap or caps H, and that the metallic packing ring or rings *g g*, which are also cut on one side, as shown at *d* in the plan, Fig. 6, are covered by a segmental piece, *e*, which fills the annular rabbet or recess on the top side of the ring, as shown in Fig. 6. The said segmental piece is beveled slightly along its entire length and depth on the outer side, so that its entire length and depth shall not bear against the inside parallel surface of the cap or caps H, thereby insuring a uniform contact between the inner bored parallel surface of the cap or caps and the upper part of the outer reduced area of the packing-ring, even should the surfaces of the port-face and steam-chest cover not be perfectly parallel. As the segmental piece *e* is pressed tight against the projecting flange of the junk ring or rings F it prevents any steam from escaping at the part where the cut in the ring *g* is made. The holes or radial slots in the edge of the junk-ring, (see Fig. 7,) for carrying off any leakage of steam that may escape past the surfaces of the metallic packing ring or rings *g* through the pipe K in the steam-chest cover to the atmosphere, are so drilled that the inner edges of these holes or slots are about three thirty-seconds of an inch clear of the outside annular bearing-surface of the packing-ring, which is pressed up against the projecting flange of the junk ring or rings F, so as to prevent any leakage of steam passing through the opening or cut in the ring *g*, and which is not covered by the segmental piece *e*, before described, since the said segmental piece *e* only fills the recess which is turned on the side of the metallic packing ring or rings *g* next the junk-ring, which recess will vary in width and depth according to the size of ring adopted. The pressure of steam acting on the annular area of the cap or caps H next the valve will hold them tight against the steam-chest cover, and the pressure, acting on the larger annular area of the metallic packing ring or rings *g* next the valve, will hold them also tight against the inner surface of the projecting flange of the junk ring or rings F, thereby providing against any want of parallelism between the port-face and steam-chest cover, so that by the reciprocal motion of the valve C the cap or caps H will adjust themselves over the outer diameter of the metallic packing ring or rings *g*, and thus accommodate themselves to any want of parallelism which may exist between the surfaces of the port-face and the steam-chest cover, thereby preventing the surface of the cap or caps H from being displaced from the surface of the steam-chest cover, and insuring a tight contact between the surfaces described.

It will be seen, on referring to the drawings of the circular and rectangular slide-valves, that the area on the back of the valve not acted upon by the pressure of steam in the steam-chest is equal to the area of the inside diameter of the cap or caps H, or, more strictly speaking, is equal to the area bounded by the line of contact between the outer diameter of the metallic packing ring or rings *g* and the internal diameter of the cap or caps H. It will also be seen, Figs. 1, 2, and 8, that there is a provision made for compression in the cylinder, which compression is caused by the boiler-priming, or by an accumulation of condensed water in the cylinder when the engine is first started, by a clearance being allowed between the top of the junk-ring F and the under side of the cap or caps H, also between the top side of the valve C and the lower annular edge of the said cap or caps. The pressure of steam in the steam-chest, acting upon the lower annular area of the cap or caps H next the valve C, will hold the said cap or caps tight against the steam-chest cover, so that when compression takes place in the cylinder, one side of the valve C being raised from the port-face at each stroke of the piston B, the valve C causes the metallic packing ring or rings *g* to rise inside the cap or caps H, and when the piston B arrives at the end of its stroke compression ceases, and this side of the valve C again falls onto the port-face without moving the surface

of the cap-face H from the surface of the steam-chest cover, thereby preventing the surface of the cap or caps H from being displaced from the surface of the steam-chest cover, and insuring a tight contact between the surfaces described.

It will be seen, on referring to the drawings, that in my improved slide-valves there is no communication between that portion of the back of the valve inclosed by the cap or caps H and the exhaust-port *b* in the port-face of the cylinder for the passage of any leakage that may take place from defects in the surfaces of the cap or caps H and metallic packing ring or rings *g* into the exhaust, as this leakage would pass through the pipe or pipes K into the atmosphere; but should there be any such leakage as would cause a waste of steam from the engine, the attendant, by closing a tap or taps attached to the pipe or pipes K in the steam-chest cover, allows the pressure of the steam escaping from the steam-chest to be exerted on that portion of the back of the valve inclosed within the cap or caps H, thus reducing the valve for the time being to an ordinary slide-valve.

In a rectangular valve, C, supposing one tap only to be closed from the causes before described, the inclosed area within the cap H would be acted upon by the pressure of steam in the steam-chest; but if both taps were closed from the causes before described, the pressure of steam would act upon the back of the valve in the same manner that it would with a slide-valve of the ordinary construction. Thus, it will be seen that under the most unfavorable circumstances (as in case of accidents) my improved equilibrium slide-valves can never become more objectionable than the ordinary slide-valve at present in use, as they can either work as equilibrium or ordinary valves until an opportunity can be obtained for rectifying any part or parts that may have become deranged, thereby insuring their certainty of working, in all cases and on all classes of engines, either as equilibrium or ordinary slide-valves.

The advantages to be derived from the adoption of my peculiar circular equilibrium slide-valves, compared with the rectangular valves now in ordinary use, may be exemplified to a certain extent by taking a circular valve of twelve inches diameter, as shown in Figs. 1, 2, and 3, containing an area of about one hundred and thirteen square inches on the back of the valve, having steam-ports for admitting steam on the lead, fourteen inches in length, with an area of about thirteen square inches, the area of the exhaust-port being about thirty-seven square inches. The rectangular valve now in use, which is taken as a comparative example, is sixteen inches long and nine and three-fourths inches wide, having an area on the back of the valve of one hundred and fifty-six square inches, with steam-ports only thirteen and a half inches in length, about eighteen square inches area, the exhaust-port being about thirty-seven square inches area.

On comparing the above dimensions it will be seen that my circular slide-valve's steam-port is half an inch greater in length on the lead or opening than the rectangular one, with an area of about forty-three square inches less on the back of the valve to be acted on by the pressure of the steam in the steam-chest, which diminishes the power required for working it as compared to an ordinary rectangular slide-valve of the dimensions given, at the same time gaining, where most required, a large amount of steam-supply to the cylinders, as well as economizing its consumption by reason of the formation of the ports through diminishing the width and length of the steam-passages into the cylinder.

I make no claim in this application to the arrangement of ports shown in the drawings, as this feature forms the subject of a separate application for Letters Patent; but

I claim—

1. The combination of the reciprocating frame D and the valve C, having a lateral bearing, by frictional contact with which an intermittent rotation is imparted, as described.

2. The combination of the valve C, loose ring H, sliding in contact with the top of the valve-chest, ring F, secured to the valve, and an L-shaped packing-ring, *g*, bearing upon the rings F and H, substantially as and for the purpose set forth.

3. The packing-ring H, groove *h*, and channels *i i*, and recesses communicating with the groove, as and for the purpose set forth.

4. The combination of the valve-ring H, having a beveled inner edge, and spring I, bearing against said beveled edge, substantially as set forth.

5. The combination of the valve C, ring F, and metallic packing-ring *g*, confined between the two, and reduced to diminish its bearing on the ring F, as set forth.

6. The combination, with the L-shaped packing-ring *g*, adapted to bearing-surfaces at right angles with each other, of the overlapping segmental piece *e*, filling the recess or rabbet on the lateral side of the L-shaped ring, all as set forth.

In witness whereof I have signed my name to this specification in the presence of two subscribing witnesses.

WALTER CHARLES CHURCH.

Witnesses:

CHAS. MILLS,
47 *Lincoln's Inn Fields.*

FREDK. C. DYER,
47 *Lincoln's Inn Fields.*