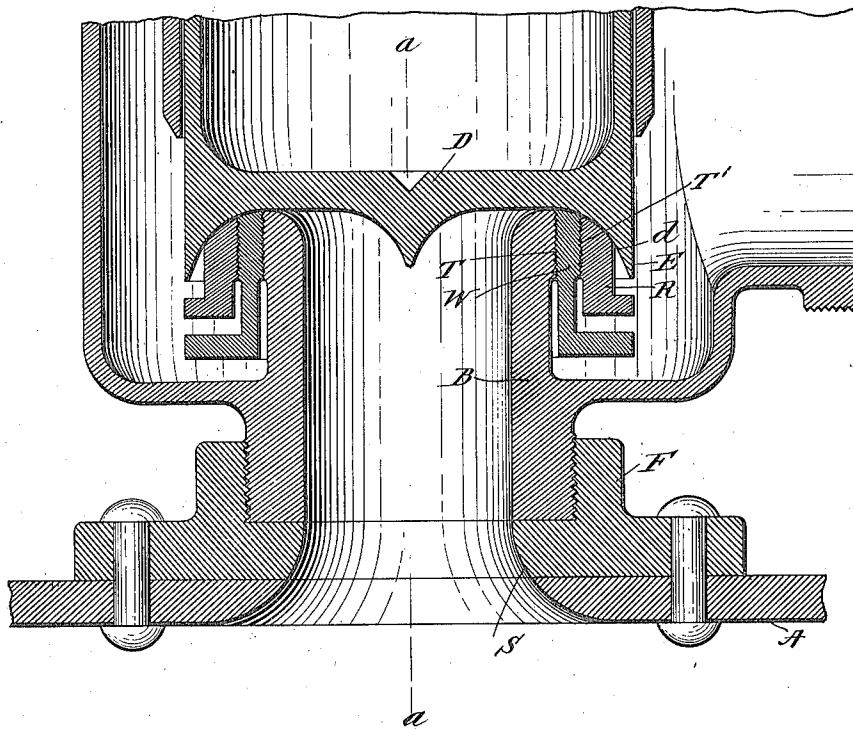


G. H. CLARK.
SAFETY VALVE.
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1,233,752.

Patented July 17, 1917.



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SAFETY-VALVE.

1,233,752.

Specification of Letters Patent.

Patented July 17, 1917.

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To all whom it may concern:

Be it known that I, GEORGE HALL CLARK, a citizen of the United States, and resident of Cambridge, in the county of Middlesex and State of Massachusetts, have invented new and useful Improvements in Safety-Valves, of which the following is a specification.

My invention relates to safety valves, and consists of improvements by which the discharge capacity of safety valves may be substantially increased without detriment to other valuable or essential characteristics of the valve.

Theoretically, the ideal safety valve would possess discharge capacity equal to the unobstructed discharge capacity of the orifice in the boiler or other container of elastic gas under pressure. This ideal has never, so far as I am informed, been realized, but it has figured in the speculations of engineers and inventors as the "full opening" safety valve. Nor, so far as I am informed, has any theoretical design for a full opening safety valve been contrived which would, even theoretically, conserve the practically essential characteristics of a safety valve, which, to satisfy engineering requirements should assume and maintain full lift, close with a small permissible blow down, and have only a limited period of "warning" at initial lift.

My invention herein described enables the engineer to design theoretically at least a full opening valve without detriment to the essential and valuable characteristics demanded of a safety valve in practice. While it may be that a complete realization of the ideal full opening valve may be difficult, perhaps impossible because of practical constructive limitations, nevertheless my invention renders it practically possible to design and construct a safety valve which will in operation approach closely, if it does not attain, to the ideal conditions of the full opening valve.

Sundry controlling or qualifying conditions should be noted as having general bearing on the design of a full-opening safety valve, either in the theoretical or practical aspect.

First: As a valve disk rises toward its maximum opening, the point of pressure control gradually recedes from the valve seat toward the inner extremity of the hole

covered by the valve disk. That is to say: When the valve disk is seated, the pressure at the seat is the full boiler pressure; this full pressure is controlling at the initial lift of the disk, but as the disk rises and the valve orifice enlarges, the pressure at the seat falls; if the maximum opening due to lift of the disk produces the condition of a full opening valve, the point of full boiler pressure will be found at the inner extremity of the hole in the boiler. Under such conditions the valve-opening will be simply a continuation of the discharge pipe, the effective sectional area of orifice being substantially equal at all points, whether in the pipe or under the valve disk.

From this it follows, that unless the entrance to the valve-controlled passage has the characteristics of a "standard orifice," the valve as a whole will not be a full opening valve in respect to maximum discharge efficiency.

Second: When full-opening conditions are attained, the lifting (or sustaining) pressure on the spring-load area of the valve disk will have become approximately 60% of the boiler pressure (absolute).

Third: On the assumption that the orifice developed by the lifting of the valve disk is a true standard orifice, the lifting (and sustaining) static pressure on the disk outside the spring load area will remain the same for practically all values of lift of the disk.

Fourth: To secure full-opening conditions, some compensatory lifting factor must be enlisted to offset the diminution in lifting pressure on the spring load area of the disk, due to the fall in pressure at that point.

Fifth: For the purpose of compensation for diminution in pressure on the lifted disk, there is available the kinetic energy of escaping steam, full advantage having already been taken of the static pressure factors.

Sixth: If the design assumes the maintenance of standard orifice conditions, utilization of the kinetic energy of the escaping steam will not detract from the discharge capacity; no changes in velocity of flow will be involved.

As stated, the theory of design implies the provision of standard orifice, if conditions most favorable to the attainment of, or close

approximation to, full-opening valve are to be secured. In an application for United States patent filed by me on February 9, 1916, Serial No. 77,318, there is shown and described a standard orifice safety valve. A "standard orifice" is one so proportioned that an elastic gas under pressure (such as steam) will, in escaping through the orifice completely fill all portions thereof and exert maximum pressure on the sides of the orifice, this pressure being approximately 60% of the absolute pressure in the container (such as the steam boiler) at a point adjacent to the throat or entrance into the orifice. This pressure is maintained on all parts of the orifice up to a point near its discharge end, where the pressure diminishes toward the external pressure. A cylindrical standard orifice will have a toric surface of approach with a radius not substantially less than the diameter of the orifice itself, and this diameter will be uniform from throat to lips (or discharge end). Thus, a "standard orifice" safety valve is one which, at a predetermined value of lift (by calculation subject to empirical correction) provides an escape orifice which is completely filled by escaping steam, and of which the effective cross sectional area at the throat (or entrance) is approximately equal to the effective cross sectional area at the lips (or discharge end).

This standard orifice condition is fulfilled by a valve disk and base having curved opposed surfaces which as they increase in radius from the valve axis as a center, progressively approach parallelism to that axis. These surfaces are toric surfaces of revolution, developed by geometric rotation about the valve axis of a curve designed to secure the aforesaid equality in cross-sectional orificial areas at the predetermined value of lift. At that value of lift a maximum lift-maintaining pressure will be exerted on the orifice-surfaces, and maximum discharge efficiency will be secured. But a valve of strictly theoretical standard orifice design will possess the practical defect of large "blow down," and should for this reason depart slightly from the simple standard orifice conformation. The practical modifications of a standard orifice safety valve, which correct the design in respect to blow down, and also in respect to "warning," without substantially impairing the standard orifice characteristics, are fully described in my aforesaid application for patent.

In the drawing hereto annexed there are shown in vertical section the parts of a safety valve which relate particularly to my invention.

D represents the lower portion of the valve disk, on which the usual valve spring (not shown) exerts its effect. B is the base,

formed in the valve casing. W is the "warning ring" adjustably screw-threaded on the base B at T; R is the "blow down" ring, adjustably screw-threaded on the warning ring W, at T'. The lips of the valve orifice are at the point d ; the valve disk D is prolonged at the lip, forming the extension E. The orifice from the boiler, formed in the valve casing may be provided with an entrance S, of toric conformation, so that the orifice normally closed by the valve disk will, if fully opened, have the essential characteristics of a standard orifice. If, however, the provision of a standard orifice entrance at this point should involve practical difficulties, it may be dispensed with, and the consequent reduction in discharge efficiency of the boiler-orifice endured. The valve orifice, however, should preserve standard orifice conditions in order to conserve the advantages of maximum discharge efficiency and maximum static lifting pressure.

As fully set forth in my said application, the blow down of the valve is reduced to a permissible value by backing the ring R away from the opposite orificial surface, and the amount of warning is adjusted to a desired value by backing the ring W away from the opposite orificial surface. The orificial surfaces are developed at the lip-point d to a nearer approach to parallelism to the axis a, a , in order to compensate for the clearance produced by backing off the ring R and to produce approximate equality between effective orificial areas at the throat and lip, respectively, of the valve-orifice at the predetermined full lift of the valve disk.

With a valve such as illustrated in the drawing, the disk, if lifted by the pressure of steam, is in part sustained by the following static factors: (1) the static pressure exerted on the spring load area, and (2) the static pressure exerted over the orificial area lying between the circumference of the spring load area and the lip at d . If, as shown in my application aforesaid, the curve of the orificial surfaces turns upward or away from the source of pressure, these static factors constitute all the available pressure resources for sustaining the disk. And, as already pointed out, the static pressure on the spring load area declines from full boiler pressure the instant the valve disk leaves its seat, and diminishes toward 60% of the full boiler pressure (absolute) as the disk lifts. Thus, if only the static pressure factors are available, a full-opening valve, or one closely approximating to full opening, cannot be obtained.

To compensate for the static pressure diminution due to lift of the valve and consequent relief by escape, I form the curved surfaces of the valve orifice so that the course of escaping steam is reversed, the dis-

charge emerging from the lips in a direction opposite (generally speaking) to the direction of lift. By making the opposed official surfaces on the disk and base substantially parallel, the direction of final discharge is the same for all values of lift. As substantial parallelism between the official surfaces is a peculiarity of the standard orifice safety valve, a valve of this type lends itself advantageously to the reverse-flow arrangement. The reactive lifting factor will be provided, by so shaping the valve, that its orifice produces a stream discharge persistently opposite to the direction of lift, preferably at all values of lift, and indispensably at the higher values of lift.

By providing a discharge reverse or opposite to the direction of lift there is added to the static pressure factors above mentioned a third lift-sustaining factor, namely, the reactive effect due to the direction of final discharge. The kinetic energy of the steam is thus enlisted; the reactive thrust in the direction of lift increases in quantity as the volume of steam per unit of time delivered increases and thus affords a lift-sustaining factor which augments while the static pressure on the spring load area diminishes. In order that the valve shall approximate closely to full-opening, the reaction-factor due to utilization of the kinetic energy of the steam must suffice to compensate for the loss in static pressure on the spring load area and must further furnish an increment of energy to compress the valve spring.

The static and kinetic factors afforded by a standard orifice valve are such that a valve which closely approximates to the ideal full opening valve may be designed well within the limitations imposed by practical structural requirements. In all cases, a lip-extension, as shown at E in the drawing, is to be recommended, since the effect of such an extension is to conserve the reverse direction of the jet or stream at high values of lift.

While, as intimated above, a substantial measure of the advantages of a full opening valve will be secured even if the boiler orifice itself be not shaped to conform to standard orifice conditions, the full efficiency obtainable will require the provision of standard orifice conditions both in the boiler orifice and valve orifice. Thus, if the valve is secured to the boiler by means of a saddle, or reinforcing ring, such as indicated at F, the surfaces of the base B, saddle F and opening in the boiler shell A, should be shaped so that when all these parts are assembled, their adjoining surfaces will form together a curved surface of approach, at S, which has a radius preferably not less than the diameter of the cylindrical orifice below the valve disk D. By eliminating all abrupt shoulders, corners or edges, in the approach

to this boiler orifice, the entire passage, including boiler orifice and valve orifice, will, when full-opening conditions are attained, become a standard orifice, capable of delivering the maximum quantity of steam which can pass through an orifice of the size of the orifice below the spring-load surface of the valve disk.

What I claim and desire to secure by Letters Patent is:

1. In a safety valve, the combination of a disk member and a base member, the two members having opposed official surfaces forming, when the valve approximates to full opening, a standard orifice, the discharge of said orifice directed in reverse to the direction of lift.

2. In a safety valve, the combination of a disk member and a base member, the two members having opposed official surfaces to form, when the valve is open, an orifice of discharge in a direction reverse to the direction of lift, the disk member provided with an extension in prolongation of the disk surface at the discharge end of the orifice.

3. In a safety valve, the combination of a disk member and a base member, the two members having opposed official surfaces to form, when the valve is open, an orifice of discharge in a direction reverse to the direction of lift, at the higher values thereof, the disk member provided with an extension in prolongation of the disk surface at the discharge end of the orifice.

4. In a safety valve, the combination of a disk member and a base member, the two members having substantially parallel opposed official surfaces to form, when the valve is open, an orifice of discharge in a direction reverse to the direction of lift, the disk member provided with an extension in prolongation of the disk surface at the discharge end of the orifice.

5. In a safety valve, the combination of a disk member and a base member, the two members having opposed official surfaces to form, when the valve is open, an orifice of discharge in a direction reverse to the direction of lift at all values thereof, the disk member provided with an extension in prolongation of the disk surface at the discharge end of the orifice.

6. In a safety valve, the combination of a disk member and a base member, the two members having substantially parallel opposed official surfaces to form, when the valve is open, an orifice of discharge in a direction reverse to the direction of lift at all values thereof, the disk member provided with an extension in prolongation of the disk surface at the discharge end of the orifice.

7. In a safety valve, the combination of a disk member and a base member, the two members having opposed official surfaces

forming, when the valve approximates to full opening, a standard orifice, the discharge of said orifice directed in reverse to the direction of lift, the disk member provided with an extension in prolongation of the disk surface at the discharge end of the orifice.

8. A safety valve and its adjuncts, comprising a boiler-orifice and valve orifice, both of which possess the essential characteristics of standard orifice.

9. A safety valve and its adjuncts, comprising a boiler orifice and valve orifice, both of which possess the essential characteristics of standard orifice, the orificial surfaces of the valve orifice being curved to form, when the valve is open, an orifice of discharge in a direction reverse to the direction of valve-lift.

Signed by me at Boston, Massachusetts, this 29th day of March 1916.

GEORGE HALL CLARK.