THE LEVER SAFETY VALVE.*

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Any person who has been present during an examination of engineers by a board of Government inspectors, will have observed the general promptitude and confidence with which questions are replied to relating to the details of every-day practice, or what should be done in case of emergency or accident.

But sometimes a change comes over this state of affairs, when the candidate is asked to solve arithmetical questions relating to the strength or staying of boilers, and other allied questions. A want of self-confidence at once sets in; he is in a fog, and it is sometimes disagreeable to be a witness. I have observed that questions about safety valves presented the greatest difficulty. This should not be. It is not the fault of the candidate; the fault lies in the obscure and perfunctory manner in which he has been instructed. The mere learning of abstract truths may qualify a student for college honors, but the mechanical engineer, before he can master the subject, must experimentally demonstrate each truth with his own hands, and under every possible variation in detail that he can think of.

The safety-valve problem is generally solved in accordance with the principle of virtual velocities. I prefer to treat it as a simple case of parallel forces in equilibrium on the axis of the valve, which is necessarily true in any position of the pea or weight when at work. There have been ideas patched on the lever which answered as puzzles or conundrums. I prefer to take the common safety valve as I find it, with the lever hinged at one end, the pin forming a fixed point on which the lever is free to turn. The downward parallel forces in the system are the weight of the valve, the lever, the pea or weight, and the pressure of the lever on the pin. Acting parallel to but directly opposed to these forces is the steam pressure in the boiler, the purpose of the arrangement being that the downward forces in the system shall resist and overcome a pressure of steam, up to a certain pressure per square inch on the surface of the valve exposed to this pressure; and if the pressure of the steam rises above this, the valve is lifted from its seat and steam escapes from the boiler.

To prepare the way towards an arithmetical solution of questions in connection with a safety valve, and that might be presented by a board of examiners, I have considered it best to briefly exhibit a few common mechanical truths that bear upon the question; they can be experimentally proven at any time, and I will use no other data in the solution of the question.

I have said that I would treat the safety-valve problem as a case of parallel forces. The acting forces are first, the weight of the parts; second, the resulting or equivalent pressure due to the pin, which varies according to the position on the lever of the pea or weight, and third, the pressure of the steam on the exposed surface of the valve. The directional lines of force are parallel to each other in a properly made safety valve, and all systems of parallel forces have a centre or resultant. Take any weights at hand, hammers, sledges, bricks or stones, and place them at random here and there on the face of a two or three-inch plank. It is evident and indisputable that there is some intermediate place between the ends of the plank where it would balance on the edge of a fulcrum. When in equilibrium, if we imagine a vertical plane passing through the edge of the fulcrum on which the plank rests, the centre of the parallel forces in the system, and its centre of gravity, lies somewhere on that plane. On this subject there are niceties and refinements that for the solution of our question it is unnecessary to detail. All that is required is to balance a safety-valve lever on the edge of a cold chisel, and when in equilibrium, a vertical line drawn on the lever from the edge of the chisel locates for all practical purposes the position of the centre of force, or the resultant due to gravitation.

It is evident that in equilibrium the lever acts as if its whole weight was concentrated at a point on the plane that is vertical to the fulcrum edge on which it rests. This is a universal law of all bodies or systems of bodies under the influence of gravity. And it is for this reason that in the safety-valve problem a single force equal to the weight of the lever is supposed to act at the place where it balanced on the edge of a fulcrum.

To master a question such as the one on hand, it is necessary that we be able to see the "reason why" in every step of the solution. The word resultant is simply the result as a whole, and in this case there is associated with it the idea of direction with the amount. Returning to our experimental plank balanced on a fulcrum, if it was suspended by a cord from the same place that it rested on the fulcrum, it would be in balance still, and the vertical line of the cord points out the location and direction of the resultant, which in amount is equal to the weight of the plank with all the bodies resting on it. If the weight of the plank with everything on it is 75 pounds, then the resultant is equal to 75 pounds, whether it be in the form of a pressure on a fulcrum or a tension on a wire or cord. This can be proven by making an experiment on the platform of a scale, or suspending it from a steelyard. The valve in place acts as a direct weight, and being of a regular figure its resultant coincides with its axis. If the pea or weight is a ball, its resultant passes through its centre, or if of any other regular figure the resultant passes through its geometrical centre.

The resultant of the parallel forces in any form or design of lever safety valve, is necessarily located at some intermediate position on the lever. We have now arrived at a general principle of the lever when the forces are parallel, that in equilibrium the intermediate weight pressure or tension is equal to the sum of the outside ones. This generalization presents a simple solution of all lever safety valve problems.

A vertical to the axis of the valve indicates the point where, in equilibrium, the steam pressure must be equal to the sum of the opposing forces in the system. If the area of the valve is six square inches, the total pressure of steam on the valve at 80 pounds per square inch, is 480 pounds. To be in equilibrium, the weight of valve, lever and pea added to the pressure, or its equivalent weight at the pin, must equal 480 pounds. Let the weight of valve, lever and pea be 75 pounds, then the required pressure at the pin is 405 pounds, and the question now takes this simple form: Where must the pea be placed on the lever to produce that pressure, or be in balance with a weight of 405 pounds, hung from the pin hole?

Here we come in contact with the principle of the "equality of moments" on both sides of a fulcrum when the lever is balanced. To find the equivalent weight of a pressure is a case of equality of moments.

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