THE LEVER SAFETY-VALVE.

THE following interesting article on the safety valve is reproduced from a late issue of The Locomotive.

GENERAL REMARKS. We have received so many requests for a rule for calculating the position of the weight on a safety-valve, and the blowing-off pressure when the position of the weight is given, that we have thought it wise to publish such a rule in The Locomotive. It would be easy to give a simple formula for the purpose, but we have considered that the wants of engineers would be best met by explaining the theory of the lever-valve, and showing, as clearly as possible, the reason for each step in the calculation.

OBJECT OF THE SAFETY-VALVE.—The object of the safety-valve, as every one knows, is to prevent the pressure in the boiler from rising to a dangerous point,

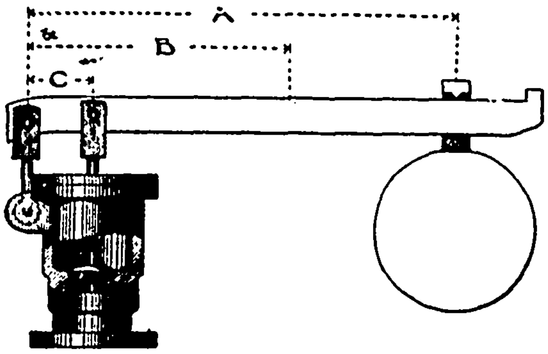

FIG. 1—DIAGRAM OF A LEVER SAFETY-VALVE.

by providing an outlet through which steam can escape when the pressure reaches a certain limit, which is determined by the strength of the boiler, and by the conditions under which it is to work. The simplest device for attaining this end is the "dead-weight" valve, the principle of which is illustrated in Fig. 2. It consists simply of a plate of iron, laid upon a nozzle, and held down by a weight. The calculation of the blowing-off point of such a valve is very simple. In the valve here shown, for example, the steam acts against a circle two inches in diameter. The area of a two-inch circle is 2×2×.7854=3.14 sq in., and the weight tending to hold the cover plate down being 314 lbs., it is evident that the valve will not blow off until the steam pressure reaches 100 lbs. per square inch. Dead-weight valves are used somewhat in England, but they are seldom met with in this country, the commoner form here being that suggested in Fig. 1. It may be well to say that Fig. 1 does not purport to be a good form of valve. We should certainly object to it, if it were placed upon a boiler offered to us for insurance, because no guides are provided for the lever or for the valve stem. These features were intentionally omitted in the engraving, in order that their presence might not draw the attention away from the main points under consideration — the calculation, namely, of the blow-off pressure and of the position of the weight.

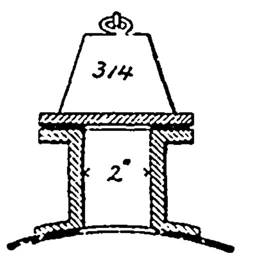

FIG. 2—A "DEAD-WEIGHT" VALVE.

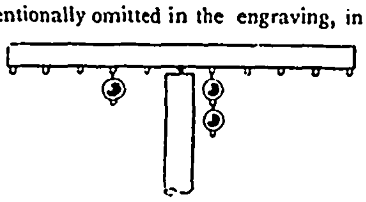

FIG. 3.

THEORY OF THE LEVER.—In order to be able to perform safety-valve calculations intelligently, one must have a clear idea of the principle of the lever; and it is hoped that such an idea may be had from a study of the illustrations that are presented herewith. These represent a lath or other light piece of wood which is balanced upon a knife edge, and into which on the under side a number of small staples are driven at equal distances. A number of balls of lead are also supposed to be provided, all exactly alike, and all being furnished with a hook at the top and a staple at the bottom. Two of these weights, when hung upon the first staple, as shown in Fig. 3, will just balance one weight hung upon the second staple, on the other side of the fulcrum. In the same way, four of them, when hung upon the first staple, as shown in Fig. 4, will just balance one hung upon the fourth staple. Five upon the second staple, as shown in Fig. 5, will just balance two upon the fifth staple; and three upon the fifth staple will just balance five upon the third staple, as shown in Fig. 6. It will be seen that in every one of these cases the lath is balanced, provided the weight upon one side, when multiplied by its distance from the fulcrum, is equal to the weight upon the other side, multiplied by its distance from the fulcrum. This is the principle of Archimedes, and it is used in all calculations relating to the lever. (The reader may find it a profitable exercise to show that the systems shown in Figs. 7 and 8 are balanced. A suggestion is afforded him in Fig. 7, while in Fig. 8 he is left entirely to his own resources. He should find no difficulty in either case, however, if he has grasped the fundamental idea which is contained in the illustrations given above).

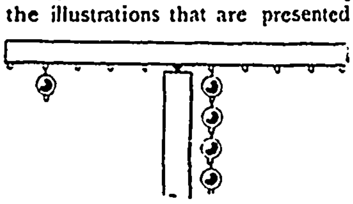

FIG. 4.

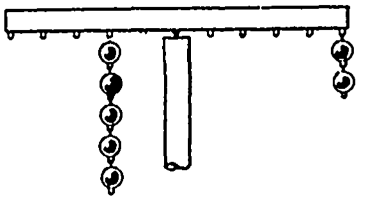

FIG. 5.

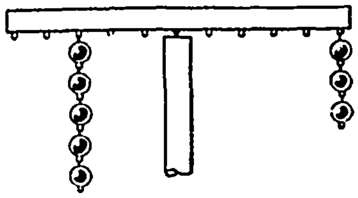

FIG. 6.

APPLICATION TO THE SAFETY-VALVE.—We are now prepared to apply the principle of the lever to the safety-valve, although there is still one point to be cleared up before we can give a complete rule. (The point to which we refer is the influence of the weight of the arm which carries the ball; but for the present moment we shall consider this arm to be devoid of weight, and we shall introduce a correction for it later on.) Fig. 9 is a crude representation of a safety-valve, in which the total steam pressure against the disk of the valve is supposed to be 40 lbs., and the ball is supposed to weigh 10 pounds. If the valve stem is 6" from the fulcrum, the ball will have to be 24" from the fulcrum in order for the valve to blow off at the given pressure —that is, at 40 lbs. This is easily seen, since 6×40 equals 10×24; but if the reader has any doubt about the applicability of Archimedes' rule in this case, he may note that the upward pressure due to the steam can be conceived to be replaced by a 40 lb. weight hung 6" to the left of the fulcrum, as indicated by the dotted circle. The lever will then be equivalent to the one shown in Fig. 10, which is similar in all respects to those shown in Figs. 3 to 8, and to which Archimedes' rule plainly applies. If the blowing off pressure were not given in Fig. 9, and we were required to find it from the other data there shown, we should reason as follows: When the valve is on the point of blowing off, the upward thrust of the valve-stem is just balanced by the downward tendency of the ball; and, therefore, from Archimedes' principle, 10×24 must equal 6 times the thrust of the valve-stem. But 10 × 24 equals 240, and hence 240 is 6 times the thrust of the valve-stem, and 240÷6 (= 40 lbs.) must be the total pressure exerted on the disk of the valve when it is about to blow off. If the pressure per square inch were desired, we should have to divide 40, the total pressure on the valve disk, by the area of the disk in square inches.

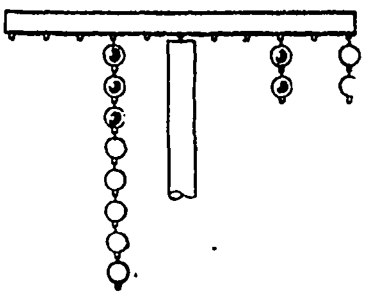

FIG. 7.

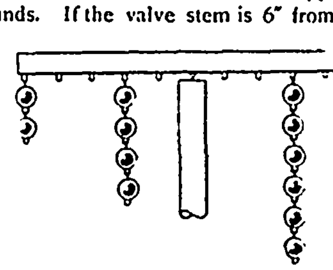

FIG. 8.

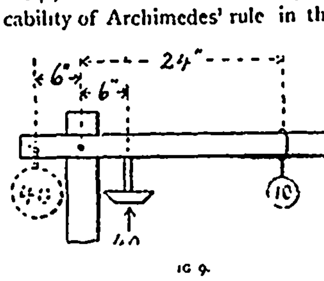

FIG. 9.

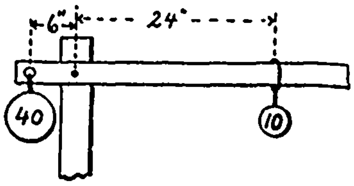

FIG. 11.

THE ARM OF THE VALVE.—In order to take the weight of the valve-arm into account, we shall first make a short digression for illustrating the meaning of the expression "center of gravity." Consider, first, the system shown in Fig. 11, where there is one ball on the first staple and one on the fifth. The one ball on the fifth staple is equivalent to five balls on the first one; so that the two balls on the right hand side of the fulcrum are equivalent to six balls suspended from the first staple. They are therefore balanced by the two balls on the third staple; and, in general, if two balls be hung from any of the staples, they would be exactly balanced by a pair of balls whose distance from the fulcrum was the average of the distances from the first two. Fig. 12 is a further illustration of this fact. Now, referring to Fig. 13, let us conceive the valve-arm to be without weight, except two small and equal pieces of it, whose distances from the fulcrum are respectively 10" and 20". By analogy with the two preceding illustrations, we see that these two little masses would be just balanced by a similar pair of masses, spaced at equal distances; they would be just balanced by four similar masses, hung at a distance from the fulcrum equal to half the length of the arm. While this kind of reasoning is applicable, strictly speaking, only to the case in which the valve-arm is of equal thickness and width throughout, and has no irregularities whatever, we may, in practice, apply it to all valve-arms approximately uniform in cross-section; and by extending the conception of Figs. 13 and 15 until the little masses become so numerous as to fill the entire lever, we conclude that a valve-arm of this sort would be balanced by a similar arm suspended (as shown in Fig. 15) at a distance from

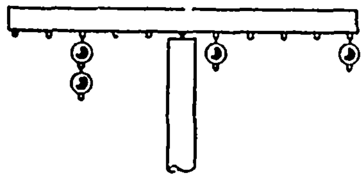

FIG. 11.

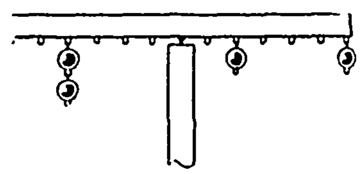

FIG. 12.

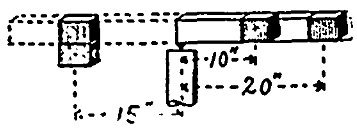

FIG. 13.

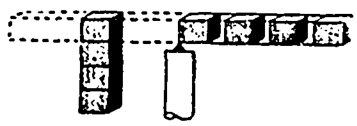

FIG. 14.

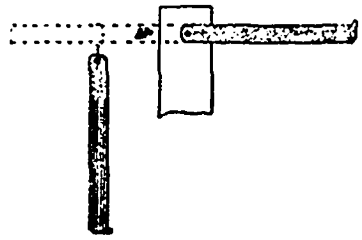

FIG. 15.