l=length of short lever in inches 4
W=weight in pounds 50
w=weight of lever arm a, valve v and stem s in pounds 20

$$\text{Formula 7: } x=\frac{A\,p\,l-W\,L}{w}$$

$$\text{Distance } x=\frac{20\times30\times4-50\times40}{20}=20 \text{ inches.}$$

THE GRADUATION OF SAFETY VALVE LEVERS.

For great accuracy in finding the centre of gravity g, the weight of valve v and stem s should be weighed with the lever arm a; and they also should be placed on the lever at their proper distance from fulcrum f when the lever arm a is balanced over a sharp edge. As before stated, the momentum wx of the lever is found by multiplying the weight of lever arm a, valve v and stem s by the distance x from the fulcrum f to the centre of gravity g, which is a constant quantity in the graduation of the lever for different pressures of steam.

Example 8.—A safety valve of the following dimensions, the lever to be graduated from 30 to 80 pounds to the square inch.

First find the weight W required for a steam pressure of 80 pounds to the square inch, which number is to be marked on the lever 30 inches from the fulcrum f.

A=area of valve in square inches 3
p=steam pressure in pounds per square inch 80
L=length of long lever in inches 50
l=length of short lever in inches 2
w=weight of lever arm a, valve v and stem s in pounds 4
x=distance from fulcrum f to centre of gravity g in inches 7.5

$$\text{Formula 2: } W=\frac{A\,p\,l-w\,x}{L}$$

$$\text{Weight } W=\frac{3\times80\times2-4\times7.5}{30}=15 \text{ pounds.}$$

The weight W required to balance steam pressure p=80 pounds to be placed on the lever L—30 inches from the fulcrum f.

Now find the long lever L, or at what distance from fulcrum f shall the weight W=15 pounds be placed to balance a steam pressure of p=30 pounds to the square inch.

$$\text{Formula 3: } L=\frac{A\,p\,l-w\,x}{W}$$

$$\text{Distance from fulcrum } f-L=\frac{3\times30\times2-4\times7.5}{L}=10 \text{ inches.}$$

Then measure off this distance L=10 inches on the lever arm a from the fulcrum f, and mark it with the number 30; divide the distance between the first and second positions of the weight into 80—30—50 equal parts, and number them from 30 to 80 consecutively. The lever is thus graduated for the required pressure of steam by 1 pound of difference per square inch.

The following method of calculating the weight area of safety valves is used by Morris, Tasker & Co., incorporated, of Philadelphia, furnished them by the late Robert Briggs (see Fig. 11).

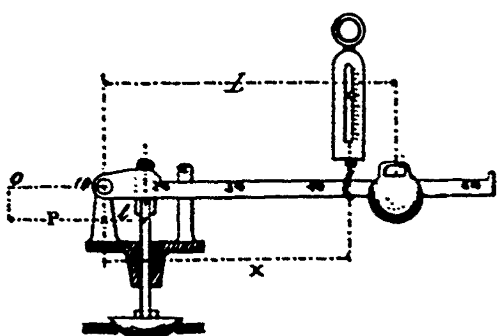

FIG. 11.

First. Multiply the area A of the valve v in square inches (0.7854 D^2) by 10 pounds (or whatever unit of pressure per square inch is taken to form a division of the lever).

Second. Multiply the short lever l, in inches by the area A in square inches and the 10 pounds (the divisions of the lever), which will give 10 A l, which will equal the *momentum* of the pressure on the valve at 10 pounds pressure p, per square inch on the short lever l.

Third. Divide the momentum 10 A l by the weight W, having assumed a weight W which it is desirable to use; the result is the length in inches of each division of the lever which will indicate 10 pounds pressure p on the valve surface.

Fourth. Remove the weight W from the lever arm, hook on a spring balance at some ascertained distance x, in inches from the fulcrum f, and lift the lever arm, valve v and spindle s from its sit by the balance. Take the weight w indicated and multiply it by the distance x, and the result will be the *momentum* of the weight W, and the result will give the length of an imaginary line P, behind the fulcrum f, on the end of which if the weight W were hung it would balance the lever arm, valve v and spindle s.

Fifth. The end of the line P we will call O=zero, as a new point from which the first division commences, and the following divisions are to be carried along the lever arm, as shown on the drawing.

The algebraical expression of the above rule may be set up as follows:

Let O=zero point of lever arm.
L=long lever in inches.
l=short lever in inches.
x=equal distance from fulcrum f at which the spring balance is applied.
W=weight in pounds.
w=weight indicated by spring balance.
A=area of valve v in square inches (0.7854 D^2).

$$\text{Divisions of 10 pounds each}=\frac{10\,A\,l}{W} \qquad \text{......... 8}$$

$$\left.\begin{array}{l}\text{Distance of zero point behind}\\ \text{fulcrum } f\text{, to balance lever}\\ \text{arm, valve } v \text{ and stem } s.\end{array}\right\}=\frac{w\,x}{W} \qquad \text{......... 9}$$

Practically, the pressure a safety valve lever exerts on the valve v can be ascertained by fixing it in its place, and securing the valve and stem in its proper position, and attaching a spring balance to the lever arm immediately over the centre of the valve v. If the weight W be also attached, in lifting the valve slightly the balance will indicate the total pressure which tends to keep the valve in its sit, which pressure being divided by the number of square inches in the valve area A, will give the pressure p per square inch at which steam will commence to blow off.

Example 9.—A safety valve having a diameter of 2.5 inches, its area A

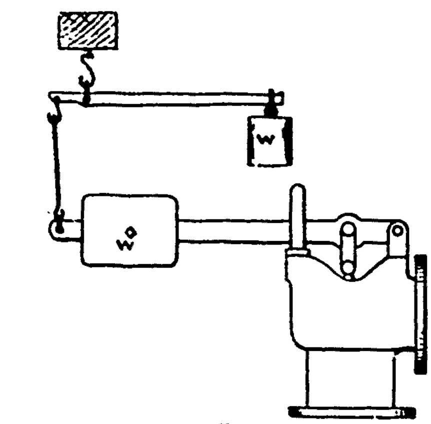

FIG. 12.

will be 4.908 square inches (0.7854×2.5×2.5=4.908). Now, in raising the lever arm a, valve v, stem s and weight W, attached the spring balance indicates 245 pounds, the pressure at which the valve will lift is the quotient arising from dividing this 245 pounds by the area A of the valve—4.908 square inches.

$$p=\frac{245}{4.908}=50 \text{ pounds pressure per square inch.}$$

The pressure exerted by a safety valve lever can be arrived at with a common steelyard as shown in Fig. 12.

SAFETY VALVES WITH BALANCED LEVERS.

Safety-valve levers are sometimes prolonged beyond the fulcrum f, and provided with an adjustable weight W, which is set to balance the weight of the lever arm a, valve v and stem s, as shown in Fig. 13.

This manner of making safety valves simplifies the calculation very much. The algebraical expression of these values may be set up as follows.

$$W\,L=A\,p\,l \qquad \text{......... 10}$$

Rule.—The weight W, multiplied by the length of the long lever L, equals the area A of the valve v, multiplied by the steam pressure p per square inch, and this product by the length of the short lever l.

$$\text{Weight } W=\frac{A\,p\,l}{L} \qquad \text{......... 11}$$

Rule.—Multiply the area A by the steam pressure p, per square inch, and

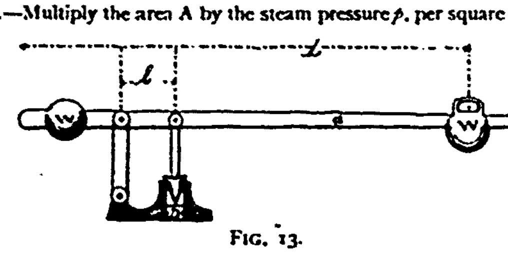

FIG. 13.

this product by the length of the short lever l, and divide this last result by the length of the long lever L; the quotient will be the weight W in pounds.

$$\text{Pressure } p=\frac{W\,L}{A\,l} \qquad \text{......... 12}$$

Rule.—Multiply the weight W by the length of the long lever L, and divide this product by the product of the area A, multiplied by the short lever l; the quotient will be the pressure p per square inch.

$$\text{Lever } L=\frac{A\,p\,l}{W} \qquad \text{......... 13}$$

Rule.—Multiply the area A of the valve v by the pressure p, in pounds per square inch, and this product by the length of the short lever l, and divide this last result by the weight W in pounds; the quotient will be the length of the long lever L.

(To be Continued.)