h, and multiply this sum by the sine of twice the angle v; second, multiply the circumference n of the valve by the vertical lift h, and by the cosine of the angle v; third, multiply the first product by that of the second, and the result will be the effective area Æ of the annular opening in square inches.

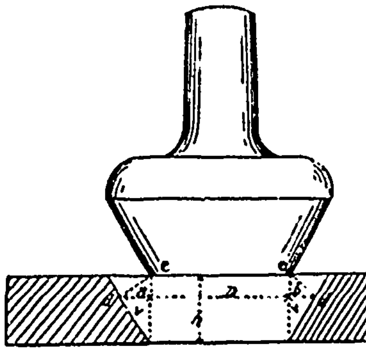

FIG. 16.

Lift of valve, the depth of sit. Angle of valve sit, 60 degrees.

Example 14.—A safety valve having a diameter D=2 inches, and the valve sit has an angle $v=25$ degrees. What will be the effective area of the annular opening for a vertical lift $h=\frac{1}{4}$, or 0.25 of an inch?

Formula 16 : $Æ=n\ h \cos v\ (D+\frac{1}{2}h \text{ sine } 2\ v)$

$$\text{Effective area } Æ=3.1416\times0.25\times0.906\ (2+\frac{0.25}{2}\times0.766)=1.157$$

square inches; or,

First, $2\times\frac{0.25}{2}\times0.766 \quad =1.627.$

Second, $3.1416\times0.25\times0.906=0.7115$

Third, $1.627\times0.7115 \quad =1.157$ square inches.

Care must be taken in not confusing 2 v, or double the angle v, with 2 sine or double sines.

It will be seen in the above example that the angle $v=25$ degrees, $25\times2=50$ degrees, and the sine of which equals 0.766 (see table). The following is a simple formula for a valve sit of an angle of 45 degrees, and lift h, less than depth of sit.

$Æ=2.22\ h\ (D+\frac{1}{2}\ h)$.. 17

Rule.—Multiply the number 2.22 by the lift h, and by one-half the lift h added to the diameter D, the product will be the effective area Æ, in square inches.

Example 15.—What will be the effective area Æ of the annular opening of a valve having a diameter $D=2\frac{1}{2}$ inches, for a lift $h=\frac{1}{2}$ or 0.5 of an inch, the angle v of valve sit being 45 degrees?

Formula 17 : $Æ=2.22\ h\ (D+\frac{1}{2}\ h)$

$$Æ=2.22\times0.5\left\{2.5+\frac{0.5}{2}\right\}=3.05 \text{ square inches.}$$

or, number.. 2.22
multiplied by vertical hight h........................ 0.5

and this product multiplied by........................1.110
the diameter D=2.5 plus $\frac{0.5}{2}$=........................ 2.75

Total square inches 3.0525

The following simple formula will also answer for angles of 30 degrees, *with a lift less than the depth of the sit:*

$Æ=1.57\ D\ h+0.68\ h^2$.. 18

Rule.—First, multiply the diameter of the valve D by the vertical lift h,

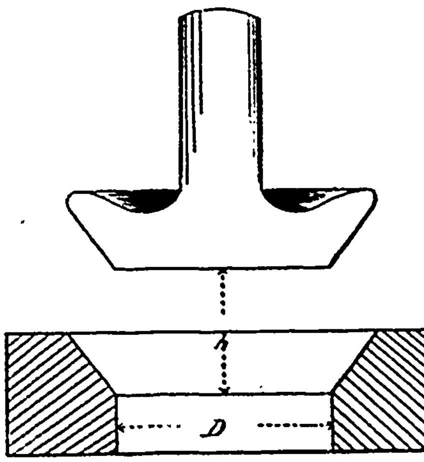

FIG. 17.

Lift of valve exceeding depth of sit. Angle of valve sit, 45 degrees.

and by the number 1.57; second, multiply the square of the vertical lift h by the number 0.68, and add the two products together.

Example 16.—What will be the effective area of a safety-valve diameter D=2 inches, having an angle $v=30$ degrees, and the vertical lift $h=\frac{1}{4}$ or 0.0125 of an inch? What will be the effective area of the annular opening for a lift h=1-16, or 0.0625 of an inch?

Formula 18 : $Æ=1.57\ D\ h+0.68\ h^2$

Effective area $Æ=1.57\times2\times0.0625+0.68\times0.0625\times0.0625=0.199$ sq. in.,
or $1.57\times2\times0.0625=$........................ 0.196250
and $0.0625\times0.0625\times0.68=$........................ 0.003656

Effective area in square inches.................... ... 0.199912

The Special Committee of the Board of Supervising Inspectors of Steam Vessels of the United States on safety valve tests at the Washington navy yard, in September, 1875, made use of the following formula. All the safety valves on trial had valve sits at an angle of 45 degrees.

$Æ=D+\frac{1}{2}h\ 3.1416\ h\times0.71$.. 19

Rule.—First, to the diameter D of the valve add one-half the vertical lift h; second, multiply this sum by 3.1416, and this multiplied by the product of lift h, multiplied by the number 0.71, gives the effective area.

Example 17.—A safety valve has a valve diameter D=2 inches, and a lift h $\frac{1}{2}$ or 0.5 inch, the angle $v=45$ degrees, what will be the effective area of the annular opening?

Formula 19 : $Æ=D+\frac{1}{2}\ h\ 3.1416\ h\times0.71$

$$\text{Effective area } Æ=2\frac{0.5}{2}\times3.1416\times0.5\times0.71=2.5 \text{ square inches.}$$

In case the lift h of the valve exceeds the depth of its sit, the area of excess of lift h is obtained as follows: Multiply the diameter D by the additional lift h, and by the circumference $n=3.1416$; this will be the area opening due to lift h above the valve sit, in square inches. Add this area to that due to the depth of the valve sit, and it will give the total effective area Æ, in square inches.

Example 18.—The diameter of a safety valve D=4 inches, and the angle $v=45$ degrees, and the depth of sit $\frac{1}{8}$ or 0.125 inches, what is the area of the annular opening for a lift of $\frac{1}{4}$ or 0.25 of an inch?

First, calculate the area of opening for a valve $v=45$ degrees, for a lift $h=\frac{1}{8}$ or 0.125.

Formula 17 : $Æ=2.22\ h\ (D+\frac{1}{2}\ h)$

$$\text{Effective area } Æ=2.22\times0.125\left\{4+\frac{0.125}{2}\right\}=1.124 \text{ square inches.}$$

Second, calculate the amount of opening due to the lift h above the sit, which, in this example, is h 1-8 or 0.125 of an inch.

Formula 20 : $Æ=D\ h\ 3.1416$

Effective area $Æ=4\times0.125\times3.1416=1.570$

Third, add these values together:

Effective area due to lift above valve sit........................ 1.570
Effective area due to lift to top of valve sit........................ 1.124

Total effective area in square inches due to $\frac{1}{4}$ inch lift=........2.694

THE VALUE OF THE SINES, COSINES AND TANGENT ANGLES, FROM 20 TO 60 DEGREES.

Angle.	Sine.	Cosine.	Tangent.	Angle.	Sine.	Cosine.	Tangent.
20°	.342	.940	.364	41°	.656	.755	.869
21°	.358	.934	.384	42°	.669	.743	.900
22°	.375	.927	.404	43°	.682	.731	.933
23°	.391	.921	.424	44°	.693	.719	.966
24°	.407	.914	.445	45°	.707	.707	1.000
25°	.423	.906	.466	46°	.719	.695	1.036
26°	.438	.899	.488	47°	.731	.682	1.072
27°	.454	.891	.510	48°	.743	.669	1.111
28°	.469	.883	.532	49°	.755	.656	1.150
29°	.485	.875	.554	50°	.766	643	1.192
30°	.500	.866	.577	51°	.777	.629	1.234
31°	.515	.857	.601	52°	.788	.615	1.279
32°	.530	.848	.625	53°	.798	.607	1.327
33°	.545	.839	.649	54°	.809	.588	1.376
34°	.559	.829	.675	55°	.819	.573	1.428
35°	.574	.819	.700	56°	.829	.550	1.482
36°	.588	.809	.727	57°	.838	.544	1.540
37°	.602	.799	.754	58°	.848	.530	1.600
38°	.616	.788	.781	59°	.857	.515	1.664
39°	.629	.777	.810	60°	.866	.500	1.732
40°	.634	.766	.839				

DIAMETER OF SAFETY VALVES.

The effective area Æ of the valve being known, and the height or lift h, the diameter can be calculated as follows: For a valve sit without bevel

$$D=\frac{Æ}{h\ 3.1416}\ \text{..} \ 20$$

Rule.—Multiply the lift h of the valve by the number 3.1416, and divide the area of opening by the product.

Example 19.—A safety valve having an effective area Æ=0.3927 when the valve lifts h—1-16th or 0.0625 of an inch. What should be its diameter:

By formula 20:

$$\text{Diameter } D=\frac{0.3927}{0.0625\times3.1416}=2 \text{ inches.}$$

or,

Number..3.1416
Multiplied by lift..0.0625

0.19635

$$\frac{0.3927}{0.19635}=2 \textit{ inches.}$$

Having given, the effective area Æ, formula 16, and the height h lifted, the diameter D is found from the above formula as follows:

$$\frac{Æ}{n\ h\cos v}-D+\frac{1}{2}\ h \sin.\ 2\ v; \text{ of which the}$$

$$\text{diameter } D=\frac{Æ}{n\ h\cos.\ v}=\frac{1}{2}\ h\sin.\ 2\ v\text{........................}21$$

(To be Continued.)