the idea of this arrangement of tubes forcing water into the same boiler from which it is supplied by pressure to operate it, might look absurd or impossible, but to us, as operative engineers, it is quite feasible; in fact we see it in successful operation every day.

We will now find out what would be the velocity of steam issuing from an opening of one square inch. If the pressure in the boiler be five atmospheres, or 75 lbs. per square inch, and the temperature of steam at this pressure be 307°F., the weight of 12 cubic inches of steam will be ·001149 pounds.

As the steam has to flow out against the atmosphere, the effective pressure, to which the flow would be due under above conditions, would be 75 lbs —15 lbs.=60 lbs. per sq. inch. If we take a pipe with . sq. inch area, and we need to put in that pipe 60 lbs. of steam (*i.e.*, 60 lbs. weight of steam), how long must the pipe be?

To find the necessary length of pipe we have only to divide the total weight, or 60 lbs., by the weight of 12 cub. in. of steam, under a pressure of 60 lbs. per sq. inch, which is ·001149 lbs.

This will give us $\frac{60}{\cdot 001149} = 52{,}218$ feet.

If we now take the formula given by D. K. Clarke for determining the velocity of steam flowing from orifices into the atmosphere, viz.:

$V = 3.59 \sqrt{h}$.

Where V = velocity in feet per second.

h = The height or length of a column of steam at the given pressure and of uniform density.

```
Then we have 52,219 (228.4 = feet
             4
          42) 122
               84
        448) 3819
             3584
      4564) 22500
            18256
             ·4344
Then   228·4
        3·59
       20556
      11420
      6852
      819.956 = velocity in feet per second, which
                steam at 60 lbs. will flow into the
                atmosphere at constant density.
```

Dr. Kinnear Clarke tells us that the lowest initial pressure for which the preceding formula for determining the velocity can be safely used, is 25·37 lbs. per sq. inch. This formula has been borne out, we are told, by the experiments of Mr. Brownlee.

There is a point regarding the flow of steam through orifices which I have only become acquainted with myself since studying up the matter for this paper, and I thought it well worthy of mention. It is this: The flow of steam of a higher pressure into a space of a lower pressure, such as the atmospheric, increases as the difference of pressure is increased, until the outside pressure is reduced to 58 per cent. of the absolute pressure in the boiler.

The flow of steam is neither increased nor diminished by reducing the outside pressure below 58 per cent. of the inside pressure, even though the outside pressure be reduced to a vacuum.

This fact was a most surprising thing when made known to me a short time ago, and I have no doubt but that it will be the same to some of my hearers in this room.

But to return to my subject. We find that steam at 75 lbs. pressure will flow into the atmosphere with a velocity of 819·9 feet per second, but this is the velocity of efflux at constant density, and D. K. Clarke tells us that the *actual* velocity of efflux expanded at 75 lbs. (absolute) is equal to 1,446 feet per second. Therefore the velocity of steam issuing from an orifice of 1 sq. inch, in a boiler carrying a pressure of 75 lbs. per sq. inch, will be 1,446 feet per second.

We will now assume that we have an orifice of 1 sq. inch in the bottom of a steam boiler, the pressure inside the boiler being the same as before, and we require to know the velocity with which water will issue from the orifice, under precisely the same conditions as in the case of steam.

Of course there will be a slight increase of pressure in the bottom of the boiler, due to the height of the water line in boiler, but as it is small, we may leave it out of the question.

Using the same method as we did for the steam (with the exception of the weight of 12 cubic inches of steam), we have now to use the weight of 12 cubic inches of water, or ·4.4, and the formula will now be

$V = 8 \sqrt{h} = 92{\cdot}8$ feet per second.

Where V = The velocity of water in feet per second.

h = 136 feet, or the height of a column of water equal to a pressure of four atmospheres.

```
Then we have—   feet
                136 ( 11·6 x 8 = 92·8 feet per second
                1
             21 ) 36
                  21
           226) 1500
                1356
                ·144
```

We now have it that steam, under a pressure of four atmospheres, will issue from an orifice of 1 square inch area at the rate of 1,446 feet per second, while the water under the same conditions will only issue at the rate of 92·8 feet per second; this means that steam will issue from an orifice with a velocity sixteen times greater than water. Notwithstanding the greater velocity of steam over water, as shown, the latter could not be forced into the boiler against its own pressure, because the momentum of the two streams is equal, because it is due to the same head or pressure.

The momentum is the product of the mass X, the velocity with which it moves, and is expressed in formula thus: $V \frac{W}{g}$ = momentum.

Where $\frac{W}{g}$ = the weight W divided by the acceleration of gravity g, which is equal to 32·2 feet per second (= momentum). The acceleration of gravity is the force (expressed in feet per second) which the earth exerts over falling bodies, in excess of the weight of the falling body itself, and is = 32·2 feet per second.

A given force imparts velocities to two bodies, inversely proportional to their mass, or their respective heaviness or density.

But by inserting the injector between the forces, we increase the momentum of the steam, and by condensing it with the water, its velocity is imparted to the water, and the stream of water and steam combined, as it were, is forced into the boiler.

A longitudinal section view of an injector is shown in diagram 4.

A is the steam cone, through which steam is admitted from boiler, and let it be distinctly understood