muſt be much rarer towards the margin of the segment. It would require a good deal of diſcuſſion to ſhow the denſity of theſe fictitious sounding points ; and we ſhall content ourſelves with giving a very palpable view of the diſtribution of the ſonorous rays, or the denſity (ſo to ſpeak) of the echoes, in the different ſituations in which a hearer may be placed.

We may obſerve, in the mean time, that this ſubſtitution of a sounding ſphere for the sounding mouth-piece has an exact parallel in Optics, by which it will be greatly illuſtrated. Suppose the cone BKDA to be a tube polished in the inside, fixed in a wall Bα, perforated in BA, and that the mouth-piece DK is occupied completely by a flat flame. The effect of this on a ſpectator will be the ſame it he is properly placed in the axis, as if he were looking at a flame as big as the whole sphere. This is very evi­dent.

It is eaſy to see that the line *leS* is equal to the line l*efa*P ; therefore the reflected sounds alſo come to the ear in the same moments as if they had come from their reſpective points on the ſurface of the ſubſtituted ſphere. Unleſs, therefore, this sphere be enormouſly large, the diſtinctneſs of articulation will not be ſensibly affected, becauſe the interval between the arrival of the different echoes of the ſame ſnap will be inſensible.

Our limits oblige us to content ourſelves with exhibiting this evident ſimilarity of the progreſs of echo from the ſur­face of this phonic ſphere, to the progreſs of light from the ſame luminous ſphere ſhining through a hole of which the diameter is AB. The direct inveſtigation of the intenſity of the sound in different directions and diſtances would take up much room, and give no clearer conception of the thing. The intenſity of the sound in any point is precisely ſimilar to the intenſity of the illumination of the ſame point ; and this is proportional to the portion of the luminous ſur­face ſeen from this point through the hole directly, and to the ſquare of the diſtance inverſely. The intelligent reader will acquire a diſtinct conception of this matter from fig. 4. which repreſents the diſtribution of the ſonorous lines, and by conſequence the degree of loudneſs which may be expect­ed in the different ſituations of the hearer.

As we have already obſerved, the effect of the cone of the trumpet is perfectly analogous to the reflection of light from a poliſhed concave, conical mirror. Such an instrument would be equally fitted for illuminating a diſtant ob­ject. We imagine that theſe would be much more powerful than the ſpherical or even parabolic mirrors commonly uſed for this purpose. Theſe laſt, having the candle in the focus, alſo ſend forward a cylinder of light of equal width with the mirror. But it is well known, that oblique reflec­tions are prodigiously more vivid than thoſe made at greater angles. Where the inclination of the reflected light to the plane of the mirror does not exceed eight or ten degrees, it reflects about three-fourths of the light which falls on it. But when the inclination is 80, it does not reflect one-fourth part.

We may alſo obſerve, that the denſity of the reflected sounds by the conical trumpet ARC (fig. 4.) is preciſely ſimilar to that of the illumination produced by a luminous ſphere TDV, ſhining through a hole AB. There will be a ſpace circumſcribed by the cone formed by the lines TBt and VAv, which is uniformly illuminated by the whole ſphere (or rather by the ſegment TDV), and on each side there is a ſpace illuminated by a part of it only, and the illumination gradually decreaſes towards the borders. A ſpectator placed much out of the axis, and looking through the hole AB, may not ſee the whole ſphere. In like man­ner, he will not hear the whole sounding ſphere : He may be ſo far from the axis as neither to ſee nor hear any part of it.

Aſſiſting our imagination by this comparison, we perceive that beyond the point *w* there is no place where *all* the re­flected sounds are heard. Therefore, in order to preſerve the magnifying power of the trumpet at any diſtance, it is necessary to make the mouth as wide as the ſonorous ſphere. Nay, even this would be an imperfect inſtrument, becauſe its power would be confined to a very narrow space ; and if it be not accurately pointed to the perſon, liſtening, its power will be greatly diminiſhed. And we may obſerve, by the way, that we derive from this circumſtance a ſtrong confir­mation of the juſtneſs of Mr Lambert’s principles ; for the effects of ſpeaking trumpets are really obſerved to be limi­ted in the way here deſcribed.—Parabolic trumpets have been made, and they fortify the sound not only in the cy­lindrical ſpace in the direction of the axis, but alſo on each side of it, which ſhould not have been the caſe had their effect depended only on the undulations formed by the pa­rabola in planes perpendicular to the axis. But to pro­ceed.

Let BCA (fig. Ç.) be the cone, ED the mouth-piece, TEDV the equivalent ſonorous ſphere, and TBAV the circumſcribed cylinder. Then CA or CB is the length of cone that is neceſſary for maintaining the magnifying power at all diſtances. We have two conditions to be fulfilled. The diameter ED of the mouth piece muſt be of a certain fixed magnitude, and the diameter AB of the outer end muſt be equal to that of the equivalent ſonorous ſphere. Theſe conditions determine all the dimenſions of the trum­pet and its magnifying power. And, full, with reſpect to the dimenſions of the trumpet.

The ſimilarity of the triangles ECG and BCF gives CG : ED = CF : AB ; but CG = BF, = ½AB, and CF

— CG + GF, = GF + ½AB ; therefore ½AB : ED = GF + ½AB : AB, and AB : ED = 2GF + AB : AB ;. therefore 2GF × ED + AB × ED = AB2, and 2 GF × ED = AB2, — AB × ED, = AB × AB — ED, and GF

— AB

And, on the other hand, becauſe AB2 — × EB AD = 2GF × ED, we have AB2 AB × ED + ¼ED2 = 2GF × ED + ¼ED , or AB — 4ED2 = 2 GF × ED + ¼ED2, and AB= √2 GF × ED + ¼ED2 + ¼ED2.

Let x repreſent the length of the trumpet, y the diame­ter at the great end, and *m* the diameter oſ the mouth-piece. Then x *= y* × y *— m*, and *y — 2xm + ¼m2 + ½m.* Thus 2m

the length and the great diameter may be had reciprocally. The useful caſe in practice is to find the diameter for propoſed length, which is gotten by the laſt equation.

Now if we take all the dimenſions in inches, and fix *m* at an inch and a half, we have 2*xm* = 3*x,* and ¼m2 = 0,5625, and ½*m* = 0,75 ; so that our equation becomes *y = √3x* 0,5625 + 0,75. The following table gives the dimenſions of a ſufficient variety of trumpets. The firſt co­lumn is the length of the trumpet in feet ; the ſecond co­lumn is the diameter of the mouth in inches ; the third co­lumn is the number of times that it magnifies the sound ; and the fourth column is the number or times that it increaſes the diſtance at which a man may be diſtinctly heard by its means ; the fifth contains the angle of the cone.