see that prolonging the trumpet must confine the sounds still more, because this will make the angle BWA still smaller ; a longer tube must also occasion more reflections, and consequently send more sonorous undulations to the ear at a distance placed within the cone *v*W*t*.

We have now obtained a very connected view of the whole effect of a conical trumpet. It is the same as if the whole segment TKDV were sounding, every part of it with an intensity proportional to the density of the points Q, R, S, &c. corresponding to the different points P of the mouth­piece. It is easy to see that this cannot be uniform, but 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 (fig. 3) to be a tube polished in the inside, fixed in a wall B *α*, 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, if 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 *l e* S is equal to the *Vine l e f a* 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 A B. 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 subject. 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 ABC (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 TB*t* and VA*v,* 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. 5) 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 A B 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, first, 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 = 2 GF + AB : AB ; therefore 2 GF × ED + AB × ED = AB2, and 2 GF × ED = AB2 — AB × ED = AB × (AB — ED) and GF