fork through a certain area it is only necessary to multiply the value of the intensity by the number of square feet in the area. For instance, if the tuning fork produces a sound intensity of 1 μwatt per square foot at the surface of a hypothetical sphere surrounding the source and the area of this sphere is 10 square feet, the total power radiated by the tuning fork will be 10 μwatts.

Since the surface area of a sphere is 4π times the square of the radius, the total power radiated by any simple source in free space will be:

$$\text{Sound power} = 4\pi r^2 I$$

Note that the intensity, I, measured r feet from the source must vary inversely as the square of this distance in order that the sound power radiated by the source remain unchanged. This is the well-known inverse-square law of acoustics. From this law it follows that the intensity must drop to one quarter for each doubling of the distance. In terms of intensity level each doubling of distance from a source is equivalent to 6 db drop in the level. This can be checked by noting that dividing the value on the intensity scale by four (Table 2b) is equivalent to a 6 db drop in the intensity level.

C. SOUND IN A ROOM WITH NONABSORBING WALLS

In a room with hard, sound-reflecting walls the radiation of sound is quite different from that shown in Figure 10. Whenever any obstacle is placed in the path of a sound wave, a reflected wave is produced. The intensity of this reflected wave will depend upon the composition of the obstacle. If it is hard and nonporous the intensity of the reflected wave will be practically equal to the incident wave.

When a sound source is completely enclosed in a room with hard walls, the sound will be reflected back and forth from wall to wall many, many times. A sound that undergoes these multiple reflections is said to reverberate about the room. Such a reverberant condition is shown in Figure 11 where, as before, the thickness of the rings indicates the intensity of the sound. Near the source the direct sound predominates, but at points closer to the walls the multiple reflections generate a rather random sound field. This situation is completely different from a sound source in an empty space (Figure 10). In the reverberant part of the sound field the sound waves come from all directions and the average sound intensity is almost uniform. The part of the field that is close to the sound source and resembles the field in Figure 10 is called the direct or free field. The part of the field that is characterized by sound travelling in all directions, the diffuse or random part, is called the reverberant sound field.

In the reverberant field the reflected sound is of primary importance, and the sound radiated directly from the source is practically negligible. The relation between sound intensity and sound pressure shown in equation 2 no longer holds since it is derived for free-field conditions. The equivalency between sound pressure level and intensity level (Table 2) will also be invalid because in reverberant sound fields the intensity level is 6 db less than the sound pressure level.

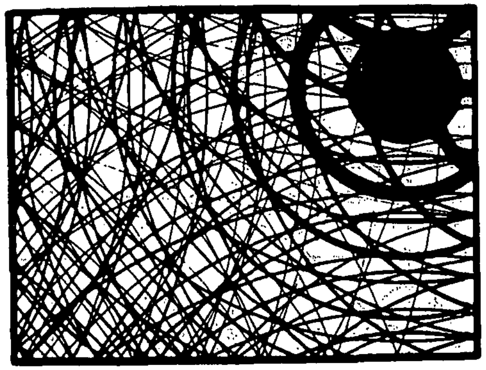

Figure 11. A graphical representation of the radiation of sound from a simple source in a reverberant room.

D. THE ABSORPTION OF SOUND

A soft, porous material, with a vast number of tiny but interconnected air spaces, is likely to absorb a large share of the sound that falls on it. The sound energy is converted into heat, but at normal intensities the resulting temperature rise is insignificant.

No material can absorb more sound than falls upon it. The pleasant picture of absorbing material sucking sound from the air is totally inaccurate. A material that will absorb sound as well as does an open window is optimum. Special shapes and arrangements are required for small local improvements over this optimum absorption and even these "superabsorbers" are no better than an open window when an average absorption over a large area is considered.

It is clearly foolish, therefore, to enclose a noisy machine with an absorbing material in an effort to reduce the sound *inside* the enclosure. The best sound absorption already surrounds the machine: empty space! This is the situation that exists in the tuning fork example shown in Figure 10. The sound source is completely surrounded by empty space and, therefore, no reflected sound waves are present.

E. THE ABSORPTION COEFFICIENT

Part of the sound that falls on any material is absorbed and part is reflected. If most of the sound is reflected, the material is nonabsorbing and is likely to have a hard, impervious surface like that of metal, bricks, concrete, or plaster. If very little of the sound is reflected, the material is absorbing and is likely to have a soft, porous surface like that of carpeting, glass wool, or snow. The fraction of incident sound intensity that is absorbed by a surface is called the absorption