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Henry, Joseph. “On the limit of perceptibility of a direct and reflected sound,“ in Scientific writings of Joseph Henry, edited by the Smithsonian Institution, 295-296. Washington D.C.: Judd & Detweiler, 1886.

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MAX PLANCK INSTITUTE
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SCIENTIFIC WRITINGS

OF

JOSEPH HENRY.

VOLUME I.



WASHINGTON:
PUBLISHED BY THE SMITHSONIAN INSTITUTION.
1886.

Ex
Biblioth. Regia
Berolinenſi.

STEREOTYPED AND PRINTED
BY JUDD & DETWEILER,
WASHINGTON, D. C.

INTRODUCTORY NOTE.

In these volumes the principal scientific writings of Joseph Henry are collected for the first time. They include his contributions to various societies and journals, together with notices of a few of his earlier communications which were never published in full. These productions, extending over a long and busy life, are naturally grouped under two periods: the first comprising the record of his researches from 1824 to 1846 (a period of 23 years), during his professorial career at Albany and Princeton; the second that of his scientific work from 1847 to 1878 (a period of 32 years), during his directorship of the Smithsonian Institution at Washington.

It will be observed that Professor Henry's contributions to science were given to the world from time to time throughout more than half a century, and published in widely remote places. Most of them are now scarce, many are practically inaccessible, hardly any individuals and few public libraries can be supposed to possess them all. It is noteworthy, and indeed is characteristic of their author, that he sedulously abstained from publishing any of his researches of the later period or reproducing any of the earlier ones—very important though he knew them to be—through the inviting channel of the "Smithsonian Contributions," or "Miscellaneous Collections," or in any way at the expense of the Smithsonian fund.

It has seemed to the Regents of the Smithsonian Institution that justice to the scientific name and memory of their distinguished Secretary who made the Institution

what it is, no less than a due regard to the history of physical science in this country, and the interests of its present votaries, require that these writings should now be collected and made available: also that their publication and distribution may be fittingly undertaken by the Smithsonian Institution. Accordingly, at a meeting of the Regents, held January 17, 1883, "Dr. Maclean having called the attention of the Board to the fact that the sundry papers of Professor Henry on scientific subjects had not been published in the series issued by the Smithsonian Institution, it was *Resolved*, That the Secretary be requested to have the scientific writings of Prof. Joseph Henry collected and published." At the next stated meeting of the Board, held January 16, 1884, Dr. Asa Gray, Hon. W. L. Wilson, and Prof. S. F. Baird were appointed a committee to supervise the publication of Prof. Henry's writings.

It was decided by them to include in this collection only the published writings of Prof. Henry, and to arrange these chronologically. A departure from this arrangement has been made in transferring the series of papers detailing Henry's extended observations on the phenomena of sound from the position of their successive dates of publication (1873 to 1877), and interpolating them between papers published in 1855. This has been done for the purpose of equalizing the size of the two volumes. The second volume is thus made to commence with the series of Meteorological Essays, which, also published originally in successive years (from 1855 to 1859), are here presented continuously. These Essays, although of a more popular character than the other writings of the author, contain much original observation and generalization, and therefore well deserve a place in this collection.

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SCIENTIFIC WRITINGS OF JOSEPH HENRY.

PART I.

FROM 1824 TO 1846.

ON THE LIMIT OF PERCEPTIBILITY OF A DIRECT AND REFLECTED SOUND.

(Proceedings American Association Adv. of Science, vol. v, pp. 42, 43.)

May, 6, 1851.

Professor Henry stated that at the meeting of the Association at Cambridge* he had made a communication relative to the application of the principles of acoustics to the construction of rooms intended for public speaking. In that communication he had stated, as an important proposition, that when two portions of the same sonorous wave reach the ear of an auditor,—one directly from the origin of the sound, and the other indirectly,—after one or more reflections, if the two do not differ in the paths they travel by a difference greater than a given quantity, the two sounds will re-enforce each other, and one louder sound will be perceived. If however the interval is greater than a certain limit, the two sounds will appear distinct, or an echo will be perceived.

As an illustration, suppose a speaker to stand before a wall at the distance of say ten feet: in this case the audience in front would hear but one sound. The direct and the reflected impulse meet the ear within the limit which he has called the limit of perceptibility. This limit—a knowledge of which is of considerable practical importance—may either be expressed in time or in space. The simplest method of obtaining its amount is that of clapping the hands, while standing before a perpendicular wall; if the distance of the observer be sufficient, an echo will be heard. If in this case the observer gradually approach the wall and continue to make the sound, at a definite point the echo will cease to be perceived, and the two sounds will appear as one. If the distance from the wall be now measured, twice the distance found will give the limit of perceptibility in space. If the same quantity be divided into the space through which the

*[This communication, made August 21, 1849, was reported by title only.—*Proceed. Am. Assoc.*, vol. II, p. 432.]

wave of sound is known to travel in a second, we shall have the limit of perceptibility in time.

The foregoing plan is the most simple—but not the most accurate—method of arriving at the quantity sought. The better plan is to employ another person to produce the sound, while the observer is stationary at the distance—at least 150 feet from the wall. The person who produces the sound being placed between the observer and the wall, at such a distance from the latter as to give a distinct echo, he is then directed gradually to approach the wall until the echo and the direct sound become one. The distance measured, as before mentioned, will give the limit required.

From a series of experiments on this plan, he found the limit of perceptibility to vary from about 60 to 80 feet, or in other words, the distance from the wall at which the echo ceased was from 30 to 40 feet. This will give from the $\frac{1}{20}$ to the $\frac{1}{15}$ part of a second, in time, for the ear to distinguish the difference of two successive sounds.

The experiments, when made under the same circumstances, gave the same result, almost within a single foot; but when a different source of sound was employed and different observers, there was observed a difference of results, giving the limits between $\frac{1}{20}$ and $\frac{1}{15}$ of a second. The limit was less with a sound produced by an instrument which gave a sudden crack, without perceivable prolongation, such as is produced by an ordinary watchman's rattle when made to emit a single crack. This difference may be explained by taking into consideration the actual length of the sonorous wave. If a sound occupies $\frac{1}{4}$ of a second, (which is about the time required for the utterance of a short, single syllable,) the length of this sonorous wave will be about 300 feet, and hence, when the distance travelled by the two sounds is not more than 80 feet to and from the wall, the two waves must overlap through a considerable portion of their whole length, and will be only separated at the two extremities. The portion of over-lapping may therefore determine the limit of perceptibility, and this again is combined with the fact of the continuance of a sonorous impression on the nerve of the ear.