ENERGY LOSSES IN RAILROAD TRACK HAMMERS.

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Growing out of the publication of my article on "Energy Losses in Commercial Hammers"[1], engineers of the Richmond Division of the Pennsylvania Railroad became interested in the problem from the standpoint of energy losses in spike and track hammers. From the regular stock they submitted specimen hammers for test. These samples had previously been rigorously tested by the railroad engineers for endurance and breakdown and reported to be of the highest quality in these particulars.

The apparatus used was similar to that employed for the testing of commercial hammers. This is the same as that employed for experiment six, page 62 in Millikan's "Mechanics, Molecular Physics and Heat." A photograph of the apparatus used in testing commercial hammers is shown in figure 1.

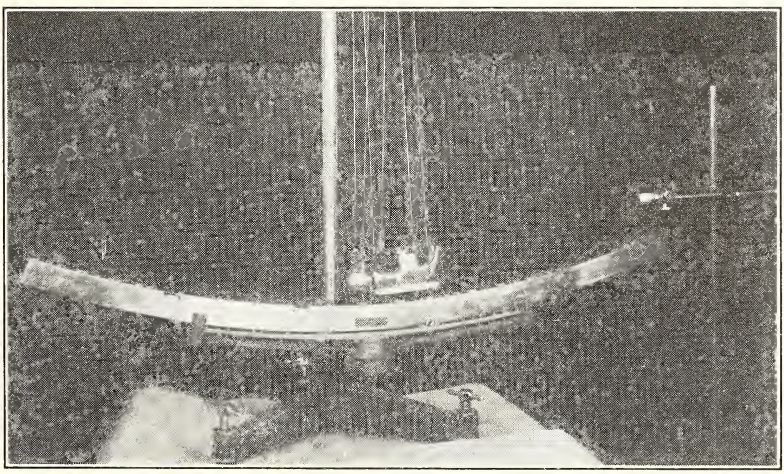

Fig. 1—Apparatus used in testing commercial hammers.

The radius of the ballastic pendulum used for the railroad hammers was about six meters, and the mass of the steel sphere was 548 grams.

The experiment consisted in displacing the hammer to a certain angular position to one side the normal position and allowing it to drop and impinge upon the steel sphere, noting the maximum angular displacement of both the sphere and the hammer after impact.

The common equations for the coefficient of restitution and the percentage loss of kinetic energy were used. For our purposes these equations as derived from figure 2 are as follows:

[1]Proc. Ind. Acad. Sci., 1918.

"Proc. Ind. Acad. Sci., vol. 37, 1927 (1928)."

$$\text{Coefficient of restitution } \varepsilon = \frac{\sqrt{1 - \cos \omega} - \sqrt{\cos \alpha - \cos \beta}}{\sqrt{\cos \alpha - \cos \theta}} \quad (1)$$

$$\text{Percentage loss of K. E.} = (1 - \varepsilon^2) \frac{m_2}{m_2 + m_1} \quad (2)$$

TABLE I. Results of Tests.

Hammer	Mass of Sphere m_2	Mass of Hammer	Mass of Hammer and Support m_1	α in Deg.	β in Deg.	θ in Deg.	ω in Deg.	ε from Eq. 1	K. E. Loss from Eq. 2
No. 1..........	232.9	659.0	782.3	2.97	6.63	11.0	15.9	.9405	2.64
No. 2..........	232.9	518.8	634.1	3.27	6.29	11.5	15.2	.8981	5.19
No. 3..........	232.9	332.6	455.9	3.00	5.71	13.0	15.5	.8406	9.92
No. 4..........	232.9	245.6	368.9	3.02	5.95	15.0	15.2	.6829	20.46
R. R. No. 1....	548.0	4,425.0	4,770.0	2.20	12.30	15.1	24.3	.8200	3.40
R. R. No. 22...	548.0	4,440.0	4,785.0	2.20	12.20	15.1	25.2	.8730	2.25
R. R. No. 3....	548.0	4,320.0	4,665.0	2.10	12.00	15.0	24.8	.8640	2.26
R. R. No. 29...	548.0	2,789.0	3,125.0	1.40	11.10	15.0	22.6	.7600	6.30
R. R. No. 22...	548.0	2,752.0	3,097.0	1.40	11.10	15.0	22.9	.7800	5.80

Note:—Hammers 1, 2, 3 and 4 are from the table published in 1918. These results are included for comparison. Hammers 1 and 2 are high grade mechanic's hammers. Hammer 4 is one purchased at a five and ten cent store.

It is of interest to note the superior quality of railroad hammers numbers 22 and 23. I have tested quite a number of different kinds of hammers and my students have also tested different types. These two hammers stand at the head of the list in energy conservation.

Appreciative acknowledgment is hereby given to my former student, Dr. Robert L. Petry, who assisted in the experimental work upon these hammers.

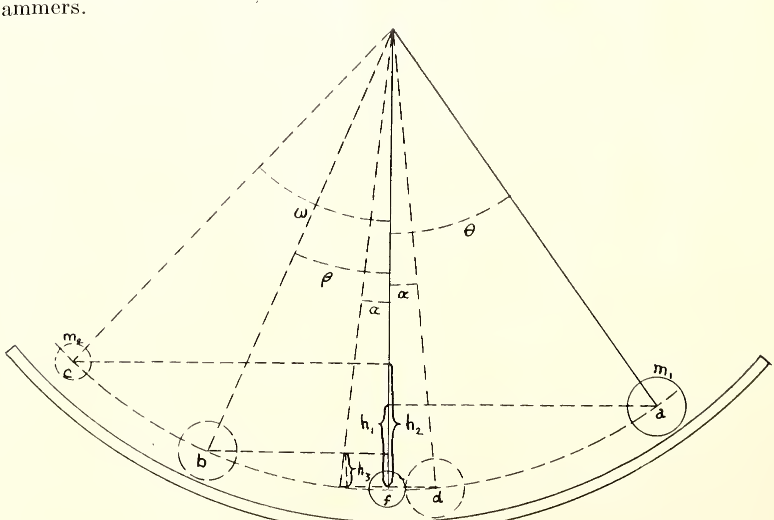

Fig. 2—Diagram used in deriving equation for the coefficient of restitution and the percentage loss of kinetic energy.