# A METHOD FOR THE ACCURATE MEASUREMENT OF SHORT-TIME INTERVALS.

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by

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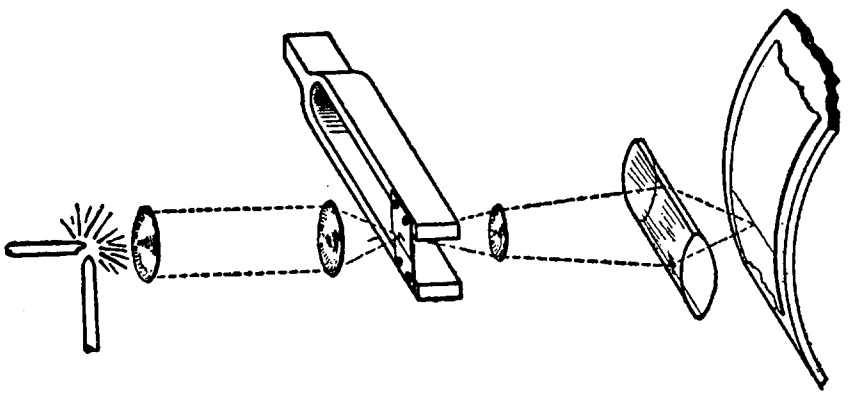
The method consists in producing simultaneously on a moving photographic film a record of the occurrence of the events under consideration and timing lines from a tuning fork acting as a shutter. The essential feature of the method is the tuning-fork shutter, which produces a ruled time scale on the developed film. Several different methods have been used for recording the occurrence of the events. Of these the oscillograph can be adapted to the largest number of problems.

The shutter consists of two opaque vanes in which narrow slits have been cut and which are mounted on the prongs of a tuning fork. The vanes are so mounted that the slits are parallel to the axis of the fork, and the two slits coincide when the fork is at rest. When the fork vibrates, the two slits will coincide twice during each complete period of the fork.

In the use of the fork the slit is brilliantly illuminated and an optical system arranged to throw an image of the slit across the moving photographic film. Then successive images of the slit will appear on the developed film as lines perpendicular to the direction of motion of the film. These lines are called timing lines. (See figure).



The accuracy of the method will primarily depend upon the accuracy of the tuning forks. Three classes are discussed in Publication 470 of Bureau of Standards: (1) Self-driven forks, (2) forks driven by a master fork, and (3) freely vibrating forks. They have successfully driven 500-cycle forks by a 50-cycle master fork. Less difficulty is experienced, however, when the ratio of periods is smaller. Very satisfactory results have been obtained using a 100-cycle fork to drive a 500-cycle one. In fact, as many as four 500-cycle forks have been driven simultaneously by one master fork using but one extra contact.

Obviously, the accuracy attainable by this method is no greater than that of the self-driven master fork.

The inaccuracies of the preceding method can be obviated by arranging to open the circuit which drives the high-frequency fork during the interval that the exposure is being made. Hence, during this interval the fork will be vibrating freely and will give the accuracy to be obtained from a freely vibrating fork.

There are a number of factors other than the tuning fork which may introduce errors. The most important of these are: (1) Errors in measuring distance between timing lines, (2) errors in measuring the distance on the film which corresponds to the desired time interval, (3) inaccuracies in the adjustment of the recording mechanism, (4) acceleration of the film during the recording, and (5) unequal expansion or contraction of film during the developing and drying process.

For very short-time intervals it is desirable to have a high velocity of film. However, mechanical as well as photographic difficulties arise when the speed is too high. While satisfactory records have been made with film speeds as high as 30 m/sec., yet it is seldom feasible to use speeds of more than 10 m/sec.

If the conditions are such that the errors in the tuning fork are negligible, then the error is of the order of five millionths of a second regardless of the length of interval measured. A tuning fork will easily give an accuracy of 0.1 per cent, but an accuracy of 0.01 per cent can only be attained by giving careful consideration of the factors which affect the period, such as temperature, amplitude, mounting, and method of drive. Hence, for intervals less than five-milliseconds the errors due to the fork are generally less than those due to the recording apparatus, but for longer intervals the fork errors are likely to predominate.

*Note*: We understand that the Cambridge Scientific Instruments Co., Ltd., 45, Grosvenor Place, London, S. W. 1., has also constructed a device of similar conception. This includes an oscillograph coupled with a camera, the latter having a revolving cylindrical drum fitted with an electrically maintained tuning-fork shutter.

This apparatus, manufactured for the British Electrical and Allied Industries Association appears likely to be of service for the measurement of time intervals employed in Phonotelemetry.