Calibration of an Image-Converter Streak Camera*

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A new technique for time calibrating an image-converter streak camera by repetitively photographing a standard signal displayed on a wide-band sweep-delay oscilloscope is described.

INTRODUCTION

AN image-converter camera[1] converts the optical image of a slit on the x axis (Fig. 1) to a corresponding signal on a photocathode. Electrostatic deflection and focusing is employed to sweep the y axis and project the electron image onto a phosphorescent screen. The image on this screen is then photographed with a conventional camera. To date most of the calibrations of the writing rate of image-converter cameras, that is the speed with which the slit image is swept along the y axis of the film, have been obtained by measuring the time duration and linearity (slope) of the deflection voltages which sweep the electron beam. To measure shock velocity in solids with an image-converter camera, an independent calibration of the camera writing rate is desirable. An ideal way to perform such a calibration is to photograph a series of events which occur at a known time interval or frequency. Since the streak camera writing rates used in shock wave studies in solids vary from 3 to 50 mm/μsec, calibration frequencies on the order of 1 to 50 MHz are appropriate. In order to obtain a series of time marks with a single streak of a rotating mirror or image-converter streak camera at these frequencies, a light source intensity of $\sim$300 lm/sr $\cdot$ cm^2 must be available. To obtain this magnitude of intrinsic brightness a xenon flash tube, argon explosive candle, or pulsed laser source must generally be employed. The light source must either be brought in and out of the field of view of the camera with, for example, a rotating mirror,[2] or the beam must be intensity modulated or Q switched with, for example, a Kerr or Pockels cell.[3]

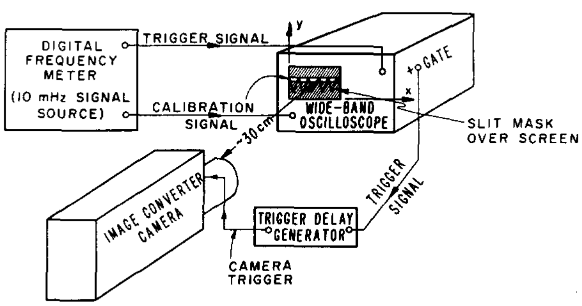

FIG. 1. Block diagram of technique for time calibration of image-converter streak camera. Trigger signal from counter is fed to "A" sweep, external trigger, "B" sweep is operated in B-sweep-triggerable-after delay-time mode. Both objective and relay lens are completely open ($\sim f/2$) since no depth of field is required.

CALIBRATION PROCEDURE

In the case of an image-converter camera relatively weak light sources may also be used for calibration, since with proper triggering the onset of the sweep and the sweep duration are reproducible to 2 nsec. For the present application we employ the masked screen of a Tektronix type 464 oscilloscope as a light source. A stable signal from a 5245L Hewlett–Packard frequency counter is displayed on the oscilloscope screen. The technique illustrated in Fig. 1 consists of streaking the camera repeatedly, as the oscilloscope sweep starts across the screen. The peaks of the standard (crystal controlled) signal from the frequency counter are displayed through a slit field of view. Although the oscilloscope displays a 1 or 10 MHz signal from the counter, the oscilloscope sweep is triggered externally at the relatively slow rate of from 1 to 10 Hz by another sig-

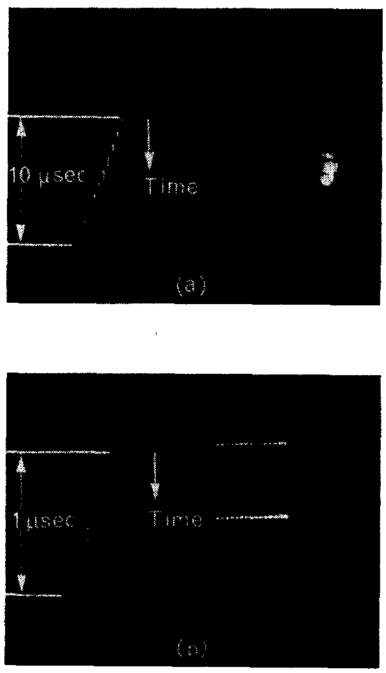

FIG. 2. Calibration photographs (type 57, 3000 speed Polaroid film). (a) (left) streak exposure—1 MHz signal, 1 Hz repetition rate, ½ h total exposure; (right) conventional picture taken through streak camera in focus position showing peaks of 1 MHz signal. (b) (left) streak exposure—10 MHz signal, 10 Hz repetition rate, 16 h total exposure; (right) conventional picture showing peaks of 10 MHz signal through streak camera in "time=0" (upper) and "focus" (lower) positions.

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[1] TRW model 1D with model 5B plug-in unit.

[2] M. Garbuny, T. Vogl, and J. Hansen, Rev. Sci. Instr. 28, 826 (1957).
[3] W. Isbell and A. Christensen, Rev. Sci. Instr. 37, 55 (1966).

nal which originates in the counter. This trigger signal is coherent with the 1 or 10 MHz standard signal to within $\sim$0.1 μsec. It is chosen such that its frequency is less than the maximum sweep repetition rate of which the streak camera is capable ($\sim$20 Hz). The trigger repetition *period* must also be greater than the decay time, $\sim$0.03 sec, of the oscilloscope screen phosphor (P31).

In order to enhance the coherence of the sweep (trigger) signal with respect to the (1 or 10 MHz) deflection signal to within several nanoseconds, the trigger from the main ("A") sweep circuit in the oscilloscope is used to drive "B" sweep in the "B-triggerable-after-delay-time" mode. The pulse delay generator (TRW, model 46A) and the streak camera are in turn triggered by the "B sweep, +gate" signal from the oscilloscope. (The +gate pulse coincides with the onset of the oscilloscope sweep.)

Using this technique the streak calibration photographs shown in Fig. 2(a) and (b) were obtained at streak-duration settings of 10 and 1 μsec, respectively. The resulting writing rates are 3.78 ± 0.02 and 43.7 ± 0.2 mm/μsec. The measurements on different photographs are reproducible within the given uncertainty of the measurements taken on one photograph.

For calibration with a 1 MHz signal at $\sim$4 mm/μsec streak rate, a repetition rate of 1 Hz for $\sim$15–30 min or 1000–2000 streak camera sweeps, is required. Appropriate oscilloscope sweep rates for this calibration are 2 or 5 μsec/div. For calibration with a 10 MHz signal at $\sim$40 mm/μsec streak rate, a repetition rate of 10 Hz for $\sim$16 h, or a total of $\sim 6\times10^6$ sweeps is required. Appropriate oscilloscope sweep rates for this calibration are 0.1 or 0.2 μsec/div.

The advantage of the present calibration technique stems from the fact that it is relatively easy to set up and usually of no extra cost since laboratories requiring streak cameras are generally equipped with digital frequency counters and sweep-delay oscilloscopes. Since the time standard (crystal control oscillator) of the frequency counter can be directly compared with WWV signals, the absolute precision of the calibration is assured. The disadvantage of the method over intense light source techniques is that relatively long exposure times are required.

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Instrument for the Measurement of Surface Tensions of Aqueous Surfactant Solutions*

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This report describes an instrument capable of accurately measuring the surface tensions of aqueous surfactant solutions with slowly varying surface areas. The instrument consists of a surface balance, a strain gauge transducer, an amplifier–indicator, and an X–Y plotter. Derivation of the basic equation demonstrates achievement of an instrumental solution analogous to the algebraic equation. A brief discussion of operational procedures outlines the method used for the retrieval of accurate data.

INTRODUCTION

RECENT studies of surface forces in the pulmonary air spaces of mammals suggest the importance of abnormalities of surface tension in many aspects of lung pathology.

Investigations reported by others indicate that lungs inflate and deflate at widely different pressures, thus producing the hysteresis apparent in a pressure–volume curve.[1] Other studies show that the ability of the pulmonary air spaces to hold air depends largely on surface tension which differs at the interface between moist tissue and air during inspiration and expiration.[2]

Development of an instrument capable of measuring the surface tension of surfactants would permit further study of the dynamic effects of surface active lung tissue. No feasible method exists for measuring surface tension in the intact lung and equating this to pressure–volume curves; however, minced lung tissue placed in an aqueous solution offers an *in vitro* substitute. This surfactant solution can then be measured with respect to varying cross-sectional areas similar to those found in normal inhalation–exhala-

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[1] M. H. Kalus, J. A. Clements, and R. J. Havel, in *Proceedings of the National Academy of Sciences of the United States of America* (Printing and Publishing Office, National Academy of Science, Washington, D. C., 1961), Vol. 47, p. 1858.

[2] J. A. Clements, E. S. Brown, and R. P. Johnson, J. Appl. Physiol. 12, 262 (1958).