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Invited Paper

SOME STROBOSCOPIC SPINOFFS IN PHOTOGRAPHIC TECHNOLOGY

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Introduction

The potential of the high speed electronic flash and the stroboscope to significantly contribute to the fields of science and technology can not be overemphasized. Important applications for these instruments and applied techniques have been described by Dr. Harold Edgerton and elaborated upon by numerous other workers.

In the School of Photographic Arts and Sciences at the Rochester Institute of Technology, fundamental principles and a variety of technical applications are a part of the education of a group of students pursuing a Bachelor of Science degree in the area of Imaging and Photographic Technology. Graduates of this program are prepared for employment in a variety of positions within a broad field encompassing industrial, scientific, engineering, and technical photography as well as technical sales support activities related to diverse photographic and other imaging specialties.

Within the context of their required coursework, students are required to complete a High-speed Photography course and may elect other courses in applied photoinstrumentation. The subject matter often is flavored with references to pioneering work developed by Dr. Edgerton.

This paper presents a summary of some of the projects included in these courses. They are presented here to not only gratefully acknowledge the direct connection to Dr. Edgerton's pioneering work but also to reemphasize the usefulness of specific electronic flash and stroboscopic analysis techniques.

Summaries of selected projects

Moving Film Stroboscopy.

In traditional stroboscopic analysis of human or mechanical movements, a stroboscope is set to repeat at a known frequency. The subject, placed against a black background, executes its motion while the shutter of the camera remains open for a brief period of time. This results in a series of overlapping exposures from which it is possible to visualize and measure the characteristics of the action.

Drawbacks of this technique are that stationary parts of the subject are multiple exposed building up density and that the recording time is limited by the eventual obscuration of motion detail by superimposition of images over previously exposed film areas.

While a number of techniques can be used to reduce superimposition and to achieve separation of exposures for stationary subject parts, the one which we have used with great success at RIT involves the manual or motorized rewinding of unexposed film into the supply cassette while the camera shutter is held open. With the slight drawback that the reference scale appears on different locations on the final print, the great advantage of the technique is that in this manner patterns of subject motion can still be perceptually decoded and velocity measurements can also be made both with the added

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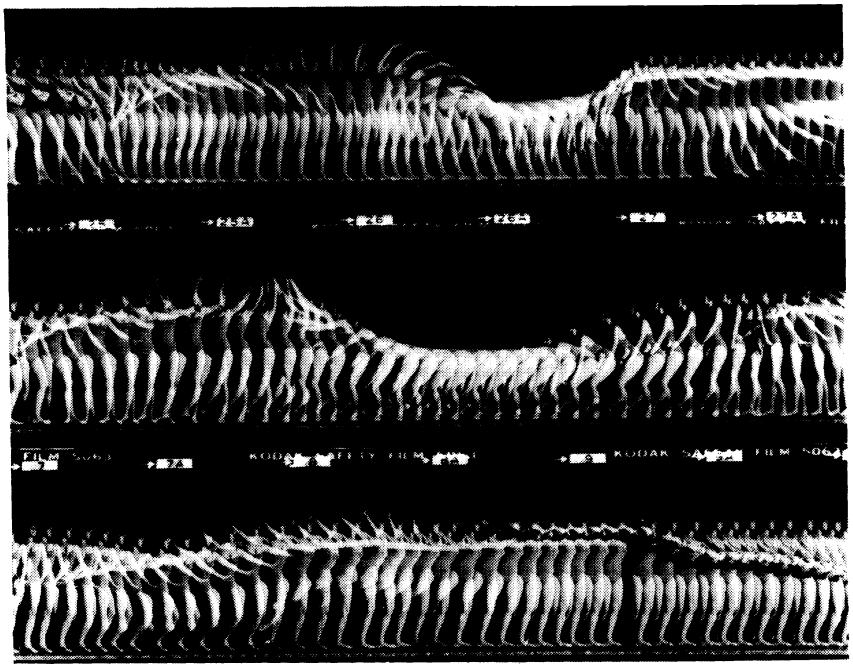
benefit that the recording time can be extended to include many subject motion cycles.



Strip Enlarging.

A direct result of the above scheme is that negatives tend to become extremely long and impossible to fit into a standard enlarger for easy magnification. In order to deal with this problem I have constructed a unique, and probably limited use, enlarger that is capable of enlarging 35mm wide negatives of any length to a maximum width of 18 inches.

The enlarger is equipped with a roller transport cannibalized from a Polaroid Pronto! camera and powered by a variable speed low voltage DC gearhead motor. The paper transport is a modified Kodak Ektamatic processor that also can transport the paper at a variable rate.

The film gate of the enlarger is reduced to a slit about 2mm wide. When the film moves in the enlarger head the paper is moved at the paper plane at a velocity that matches the rate at which the grain of the negative moves by adjusting the paper drive control. The lens aperture is adjusted to provide a proper exposure for the time it takes a particular image point to move across the image of the slit at the paper surface.

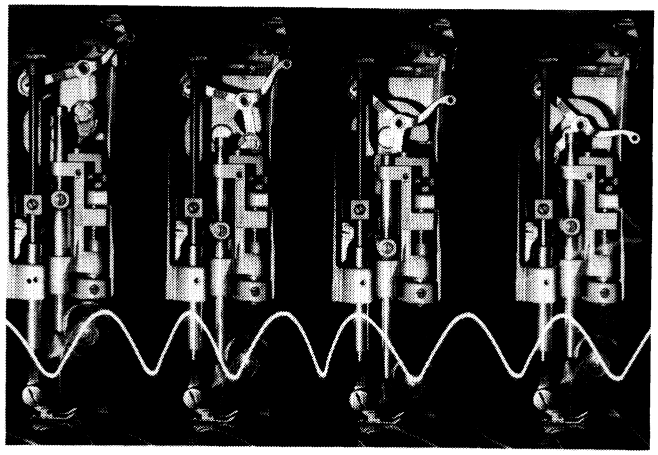
A typical paper velocity for a magnification of 10x is about 5mm per second giving an exposure time of only about 4 seconds. The brief exposure time is chosen to minimize the possibility of blur being introduced by a slight mismatch of image vs. paper velocities. Therefore, large wattage lamps are used along with relatively large lens openings. A second consequence of this "sequential" enlargement method is that it results in large differences in time between the time of exposure of the leading vs. the trailing portion of the print. For a 10x print made from a 5 feet long negative this difference often is 50 minutes or more. We do not make too many enlargements!

Combined Tungsten/Stroboscopic images for greater motion certainty.

Standard or moving film stroboscopy suffers from the fact that there is no information recorded by the photosensitive material during the "dark" portions of the exposure.

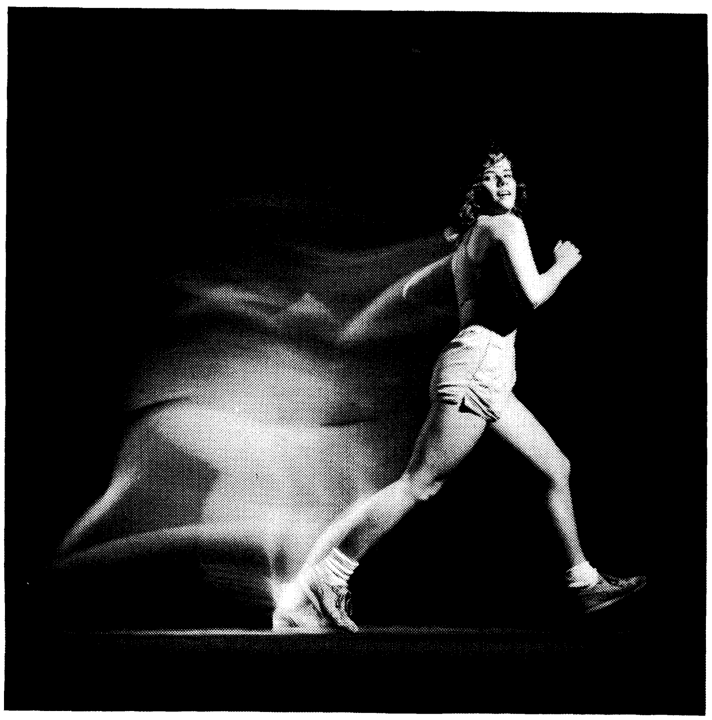
This could lead to misinterpretation of the results if frequency of operation is the parameter that needs to be determined.

To overcome this limitation, students perform moving film stroboscopic analysis of a sewing machine movement with an added feature. To insure that they do not miscalculate the stitching frequency they attach a small incandescent lamp to the needle assembly. This lamp describes a continuous record, effectively a streak record, of the lamp position vs. time. Since the stroboscope provides the time base and the instantaneous view of the position of the various machine parts, motion analysis can be performed thoroughly. As part of the written technical report that the students prepare they include a graph of stitching rate vs. voltage.



Tailflash Synchronization

One of the drawbacks of the standard "X" synchronization scheme incorporated in most current shutters is that they complete the firing circuit of the flash immediately upon reaching their fully open position. Since this causes the electronic flash to fire at that time, attempts to introduce blurb due to a simultaneous tungsten exposure typically place the blur in front of, or towards the direction that the subject is moving. Enterprising photographers have dealt with this problem by simply making the subject move backwards. When this is not possible a different approach must be taken. While some SLR cameras delay the triggering signal until their second curtain is about to close, diaphragm shutters and most existing focal plane shutters must deal with the triggering in a different way.



A rather complex way is to fire the flash after a predetermined delay introduced by a variable electronic timing device usually triggered by the standard X sync contact of the shutter.

A more automatic and simpler approach is to design a triggering device that relies on inherent electronic flash operating principles.Since electronic flashes will charge their main capacitors regardless of the sync contacts condition and since the trigger capacitors generally recharge very quickly, it is a simple matter to attach an electronic or mechanical inverting switch to the shutter or camera and cause the flash to fire just previous to the shutter closing.

This "tailflash" synchronizer must be mechanical for focal plane shutters but can be electronic for leaf shutters.

Study of Radio Tower Stroboscope with an improvised streak camera.

The behavior of another "Edgerton light" was studied in another project where the simultaneity and flashing frequency of a strobe illumination system installed on a local radio tower had to be determined.

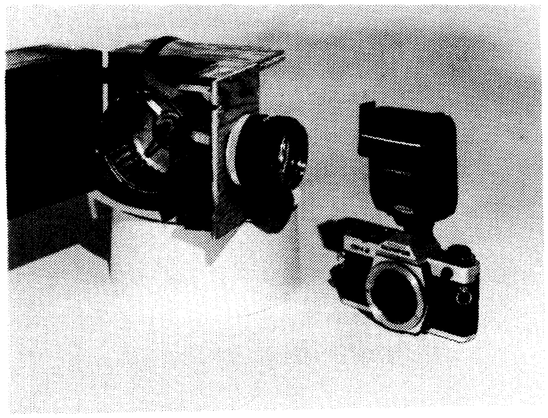
The power of the streak camera as an analytical tool for such purposes was again demonstrated. This time the camera was an inexpensive ($10) plastic bodied 35mm camera modified to accept Leica screw mount lenses and fitted with a motorized film advance system salvaged from an old Pentax film winder attachment.

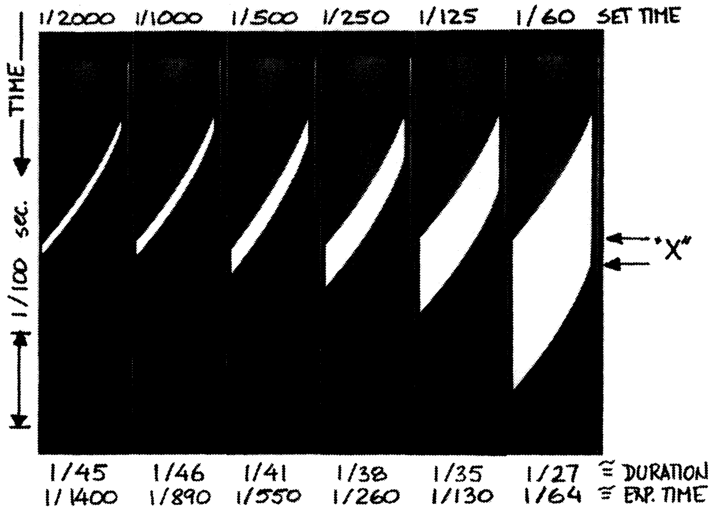
The study was conducted at night and from the resulting negatives it was apparent that the moving film clearly recorded the timing pattern as well as the flashing frequency of each stroboscopic warning beacon. The known frequency (120Hz or 1/120 sec. per cycle) of a sodium vapor street lamp, also included in the scene, was used to provide the time base on which the timing of the strobes was measured.

Rotating drum streak camera used to study novel Olympus electronic flash

A simple rotating drum camera, constructed out of plywood, a sewing machine motor, a blower fan, a lens flange and a lens, was used to study the operating characteristics of the unique F280 extended duration flash manufactured by the Olympus Corporation.

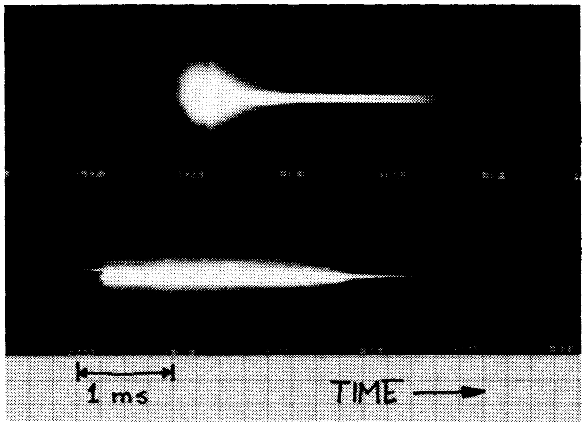
This flash can operate either in the conventional mode or in the extended duration mode. In the former case it can only be used up to the X sync speed of the camera. In the latter case, the flash allows even the top shutter speed of 1/2000 second to be used. Through this study it was determined that the flash is transformed into a high repetition stroboscope when set in the FP mode. The strobing frequency was measured to be 10KHz, the duration varied from about 1/50 to 1/25 second and the evenness of illumination across the film plane was found to be essentially uniform.





Electronic flash and exploding wire timing with a rotating drum streak camera

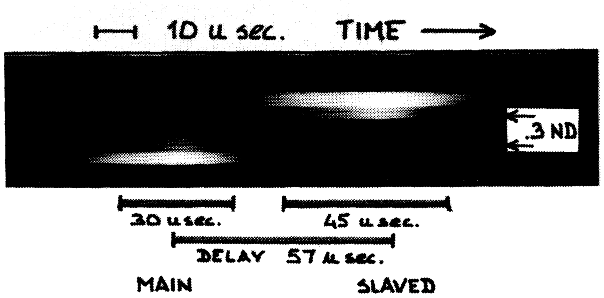
The rotating drum camera described above has been used by students to analyze the duration of a 200 watt-second Ultrablitz electronic flash at full power to contrast its duration against the duration of an exploding wire.



The exploding wire is made by stripping a heavy gauge extension cord at the end opposite the plug and connecting thin gauge soldering wire across the bare ends. Taking proper safety precautions the plug is inserted in the electrical outlet causing a brilliant flash of light as the wire "explodes". The electronic flash is characterized by extensive afterglow while the exploding wire light output was found to be more uniform but not as luminous as the light from the flash.

Timing with a rotating mirror streak camera.

While the small drum camera can be used to determine triggering delays inherent in sound and radio slave triggers as used in typical studio situations, its time resolution is not high enough to resolve time delays in the microsecond range.associated with light activated, or slave, triggers. For streak studies in this time frame the Department has available a surplus Cordin S-4 rotating mirror streak camera. Since the camera's associated timing and synchronization accessories were not functional, students have to use improvised and adapted instrumentation to generate useful data with this instrument. To determine the time base of the records, the mirror rotation rate is monitored with a General Radio Strobotac.



To determine if a record was made on the film loaded in the camera light from the subject under study is allowed to fall on a marker attached to the rotating mirror's shaft. If the flash from the subject shows that the marker appeared between previously established pointers showing proper mirror position, the test is concluded.Slave trigger delays of about 20 to 50 microseconds have been measured by students.

Conclusion

These project summaries are an indication of the fact that Dr. Edgerton's leadership and influence are alive and well at RIT. We are deeply indebted to him for making the high speed electronic flash and the stroboscope such popular and useful tools for creative applications and scientific and engineering study.