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Modulating Time: A Brief Introduction to Analytical Film Projectors

Until the invention of Edison's kinetoscope and Lumière's *cinématographe*, many of the pioneers of motion pictures were as interested in movement analysis picture by picture, frame by frame, as in their possible synthesis. French physiologist Étienne-Jules Marey and English photographer Eadward Muybridge conceived sequential photography as a sophisticated observational instrument that would bring significant granular detail to different fields of the natural sciences. In a way, projection reconstructs a recorded movement by blurring the differences between the different filmstrip frames, fusing them into a seamless gesture. However, the urge to delve deeper into the observation of single images and of modulating the filmstrip's running speed at wish led to the creation of analytical film projectors during the 1940s and until the improvement of video technologies.

Analytical projectors: their features

As analytical projectors are not a particular patent, process, or standard but rather a set of specific functionalities shared by different film projectors, there is no fixed manner of referring to them other than by the particular model used. Depending on the manufacturer and the user, they may also be called 'analyzer,' 'stop-motion,' 'slow-motion,' 'variable speed,' 'freeze-frame,' 'motion analysis,' and 'data analyzer projectors.' Expected functionalities include variable frame rates below the usual 'sound' and 'silent'

speeds (24 and 18/16 fps); the ability to project a still frame without the risk of burning the filmstrip; and the possibility of reverse-motion projection. They sometimes came equipped with accessories such as remote controls, frame counters, and daylight screens, complementing the uses the projectors were often put to.

For over three decades, starting at the end of World War II, some or all of these features were included in specialized 16mm projector models for professional use. Some of them originated from established brands such as Kodak (Analyst and Analyst II), Bell & Howell (Specialist, D-5, and Time-and-Motion), and Lafayette Instrument (Pony and AAP), or more obscure ones, like Perceptual Development Laboratories (the PerceptoScope). A few smaller companies adapted already existing analytical or standard film projectors to include a more versatile or precise use, as is the case of CECO's Weinberg Watson projector (that adapted the Kodak Analyst II with a new shutter design, a wider speed range, and a remote control switch) and the L-W 224 A and L-W Athena (building the possibility of slow-motion and freeze-frame screening into a Kodak Pageant sound projector).

For the introductory purposes of this paper, I will focus on describing four representative models of 16mm analytical projectors (the Victor Animatograph 40, the Kodak Analyst, the L-W Athena, and the PerceptoScope). Still, it must be noted that many more existed, manufactured for different gauges (most notably for 8mm and Super 8[1]) and that it is frequent to read or hear accounts about 'modified' analytical projectors in scientific or artistic settings. Modifications usually aim for a higher precision in image

[1] Some examples of Super 8 analytical projectors commercialized in 1970s are the Lafayette Super 8 Analyzer Projector model 905, the Dejur DP 99, the Focal 7000 DZ-Dual 8 Zoom, the Pathé Duo M 220 Variomatic, and the Krisper 934 Dual.

analyzing or take advantage of some of the machine's features to use it for a completely different purpose, such as optical printing.

Although it is hard to confidently determine which was the 'first' analytical projector model ever manufactured[2], the first (or closest precedent) I have been able to trace is the Animatograph 40, released by the Victor Animatograph Corporation in 1939. The projector did not market itself as analytic. It was designed for home use as part of a modular home media station sold as the 'Add-A-Unit' and also featuring a radio, a record turntable, an audio recording unit, a 'public addressing system,' and multiple speakers.[3] However, the Animatograph 40 was a 16mm sound projector that allowed still projection, frame-to-frame, and reverse advance. It featured a heat-reducing lens that may be optionally placed between the lamp and the film, avoiding burns in case of freeze-frame projection, and, more interestingly, a clutch that acts as a speed regulator for film advance. In its lowest position, the film remains still on the gate, and at its highest, it advances at normal speed (either 16 or 24 fps). The clutch may be positioned at any intermediate point to achieve a range of slow-motion speed rates. When combining this clutch with the forward or reverse advances permitted by the projector and its ability to maintain a single frame projected on the screen, we have all the capabilities of an analytical projector. As will later be mentioned, the Animatograph 40 was used as such during the 1970s by experimental filmmakers like Ken Jacobs and the film department at Binghamton University, who held four of them available for staff and students.

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2 In a way, the Lumière brothers' *cinématographe* and many of the first film projectors could already be considered 'analytical' under the set of characteristics I have given above, as they could advance in forward or reverse motion at any given hand-cranked speed.

3 Wasson, Haidee. *Everyday Movies. Portable Film Projectors and the Transformation of American Culture*. Oakland: University of California Press, 2021. p. 8-11

Eastman Kodak released two models of 16mm analytic projectors, the Analyst (1953-1973) and Analyst II (1957-1982). A 1950s manual describes the Analyst as "designed for athletic coaches, industrial engineers, and all those who wish to study 16mm motion pictures for the purpose of analyzing motion." The model allows for safe still and slow-motion projection thanks to a dichroic heat-absorbing glass filter placed between the shutter and the aperture (similar to the one used by the Animatograph 40, although the one in the Analyst is not removable), a reflecting coating on the condenser lens, and two separate motors: one to transport the film at different speeds through the projector and another one, running at a constant rate, powering the blower system and providing cooling at the gate. A 750-watt lamp came with the projector, and a 1,000-watt light could also be used. To regulate projection speed, the analyst had a continuous control wheel running from 'SLOW' (approximately five fps) to 'FAST' (24 fps). All intermediate speeds are approximate, and, although a constant speed is reached by leaving the wheel at any single position, the projectionist can never accurately know the exact rate the film is advancing at. The Kodak Analyst II has a very similar design and allows for the same range of speeds, the main technical difference is that it can only hold a much dimmer lamp (200-watt). None of these models ever permitted sound reproduction.[4]

The transporting case of both Analyst models came equipped with a 'daylight projection viewer,' a two-piece mirror and screen system devised to maximize light intensity and enable satisfactory screenings in interiors without the need to darken the room. The projected image would be aimed at a mirror, and this mirror aligned to a small translucent

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4 "Kodak Analyst movie projector." Eastman Kodak, n.d. Consulted at https://van-eck.net/en/product/kodak_analyst_movie_projector_user_manual_english/
"Kodak Analyst II movie projector." Eastman Kodak, n.d. Consulted at Mono No Aware, NYC.

screen, smaller than the size of a regular TV. Both the mirror and the screen were mounted on a solid panel meant to be placed on a flat surface.

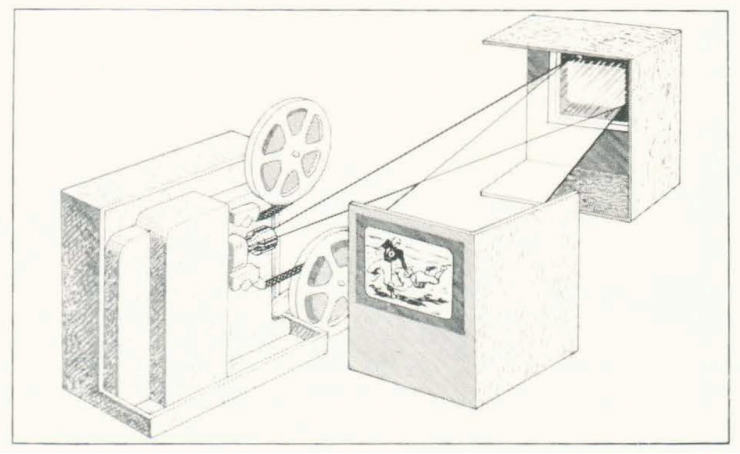

Figure I. Drawing from "Kodak Analyst movie projector." Eastman Kodak, n.d.

The few limitations regarding sound reproduction and undeterminable frame rates found in the models of many broad manufacturers, such as the Kodak Analyst, were eventually improved and capitalized upon by smaller companies. Such is the case of L-W International, a manufacturer in the US in the 1970s and 80s that specialized in motion analyzing equipment, from cameras and projectors to early digital systems of movement analysis. Their projectors were not original designs but modifications from different Kodak models. The L-W Athena, the most expensive in their catalog, was a modification of the Kodak Pageant, a popular 16mm sound projector. The Athena built six constant slow-motion speeds and a still projection position into the Pageant, improving the Kodak Analyst by permitting discreet changes between accurate frame rates (1, 2, 4, 6, 8, 12, and 24 fps) and the ability to play optical sound when projecting at 24 fps. It achieved this by inserting a heat-absorbing filter that would be automatically placed when the projector ran at any speed other than 24 fps and installing a constant blower motor that directly cooled the gate. In the following section, we will see how these slight improvements in the capabilities of the Kodak Analyst may have been of dramatic importance for some

of its users in the fields of education and scientific research. The Athena also included a microphone receptacle to use its speaker as a voice amplifier (meant for lecture situations) and a five-digit frame counter.[5]

Still another type of manufacturer of analytical projectors was companies that designed army equipment for different purposes, an example of which is the Missouri-based Perceptual Development Laboratories, Inc. In 1956, they presented the PerceptoScope, a device with a single lamp and lens and two film gates so that it could project two different 16mm filmstrips at once (superimposing them onscreen) at a range of slow-motion speeds and also 35mm slides. The PerceptoScope could work as a tachistoscope[6], still-projecting the film frames or slides for predetermined periods before advancing to the following one. The lamp was positioned at an angle, so it did not hit the gates directly, probably to afford safer still projection. The machine was equipped with a remote control switch. Ads in military magazines described it as "the new electronic aid for modern military training."[7] In a 1963 paper documenting image analyzing activities, the anthropologist Ray Birdwhistell pointed out the PerceptoScope cost the Eastern Pennsylvania Psychiatric Institute $2,000 (around $17,000 in 2021 currency).[8]

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5 "L-W International presents A World of Quality Products." L-W International, n.d. Consulted at NYU Tisch.

6 Wasson, p. 167

7 Perceptual Development Laboratories. 1956. The PerceptoScope. [Advertisement]. *Air Force: The Magazine of American Air Power*, 39. p. 113.

8 Leeds-Hurwitz, Wendy & Kendon, Adam. The Natural History of an Interview and the microanalysis of behavior in social interaction: A critical moment in research practice. In James McElvenny & Andrea Ploder (eds.), *Holisms of communication: The early history of audio-visual sequence analysis*, 145–200. Berlin: Language Science Press, 2021 p. 151

Further information on the PerceptoScope has been gathered by a visit to filmmaker Ken Jacobs, who owns and has worked for years with two of them since the late 1970s.

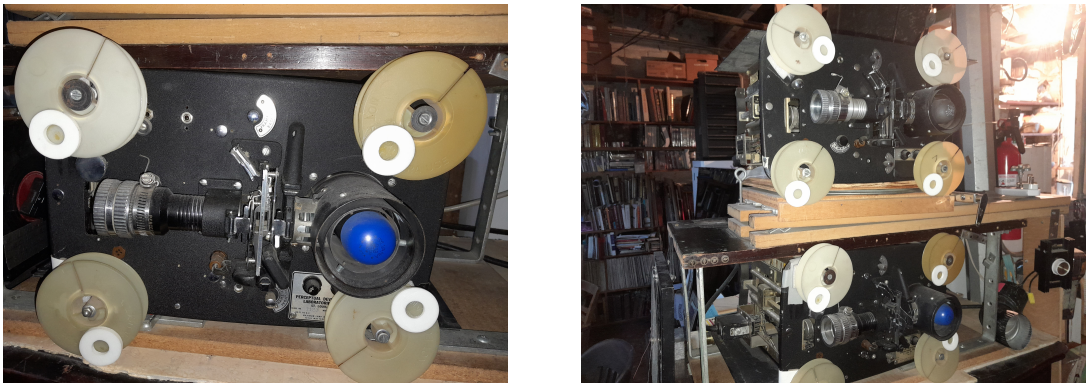

Figure II. Photographs of two PerceptoScopes at Ken Jacobs' house. Taken by the author.

From this brief overview of four different models of analytical projectors, we have been able to see the different strategies used to allow for their slow-motion and still projection:

• the first and most widespread is the use of dichroic heat-absorbing glass filters positioned between the lamp and the gate. The Victor Animatograph 40 included it as a manual lever that the projectionist should remember to set manually, but the other models included it automatically. The Kodak Analyst, for example, had it on by default and would require a special modification to remove it. In contrast, the L-W Athena automatically removed or introduced it whenever the projector changed from slow motion speed to 24 fps and back again.

• the use of a constant speed motor powering a blower directly cooling the gate was featured in many analytical projectors.

• lamps of lower wattage, from 28 to 150 watts, are found in some models, such as the Kodak Analyst II. Of course, a major inconvenience of this strategy is that the luminosity of the screened image is minimized, making potentially relevant detail invisible to the observer.

• finally, in some models, the lamp is not positioned to point directly into the gate but is either placed at an angle (as in the PerceptoScope) or focusing its light by way of a reflective mirror (as in the Lafayette Instrument 720 Sound).

Although this problem seemed to affect some models more than others, the broadest concern reported about analytical projectors' use is their tendency to tear and physically damage the film by the intermittence of its transport.

Analytical projectors: their uses

Analytical projectors have had a wide variety of uses. The most overarching ones have been in training (sports and military), education, experimental science, and avant-garde filmmaking. A history of the role analytical projectors played in team sports is still to be written. Still, scattered accounts exist on the importance of image analysis as a learning routine for professional and university teams. During the 1950s and 1960s, analytical projectors were also regularly publicized in periodicals such as *Educational Screen* and *Business Screen*. As can be deducted by frequently featured accessories such as a remote control switch and a microphone and speaker, analytical projectors were marketed as ideal instruments for lecturing, in the way slides had been since decades before. Analytical projectors found a renovated educational impulse in the 1970s with the emergence of film studies departments in universities and the popularity of textual analysis and other trends of media study that favored close material analysis of cinematographic works[9].

9 For a praise of editing tables and analytical projectors as methods of film analysis, see for example Bellour, Raymond. *L'analyse du Film*. Paris: Albatros, 1979. p. 20

However, the progressive abandonment of 16mm and 8mm projectors in these contexts throughout the 1970s and 1980s should be attributed to improving video recording and playback technologies becoming increasingly affordable. In 1967, the expert on sports image analysis Harold Hainfield wrote: "…16mm movies and, recently, with improvements in cameras, lenses, and projectors, 8mm film have been used to analyze a wide variety of individual and team performance. It takes time, however, to process film, delaying the instructor's analysis. Movies also require a semidarkened room and projector once they are developed."[10] This could be the reason to explain why, in 1969, analytical projectors "sold at a rate of roughly two thousand per year, approximately 2 per cent of the market [of film projectors],"[11] while by the late 1980s, virtually all models of slow-motion projectors had ceased manufacture and small companies wholly dedicated to film data analysis, such as L-W International, disappeared.

However, the longest-lasting and most documented use of analytical projectors has been as an instrument of enhanced observation for many fields of experimental science, from zoology, microbiology, medicine, and meteorology to anthropology, psychology, and experimental linguistics. Although scientists have made pioneering use of all video and digital technologies as soon as they were engineered, accounts of the use of 16mm analytical projectors have been found up until the late 1990s.[12] As is frequently noted,

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10 Harold Hainfeld. 1967. Photography in Sports, *Journal of Health, Physical Education, Recreation*, 38:8, 83

11 Wasson, p. 166

12 The latest I could find dates to 1998:
Asymmetrical Force Production in the Maneuvering Flight of Pigeons. Douglas R. Warrick, Kenneth P. Dial and Andrew A. Biewener *The Auk*, Oct., 1998, Vol. 115, No. 4 (Oct., 1998), pp. 916-928

film was used to record "events that were in need of better image resolution than could be provided by the video tapes."[13]

For scientific uses, analytical projectors were often used in conjunction with what was called in the 1970s a 'film digitizer,' devices that would register in mathematical form the movement found through different filmstrip frames. The projected image would be pointed to a screen on the digitizer. The machine would divide the image's surface in two-dimensional coordinates, an X and Y axis, recording every movement in selected picture areas.[14]

An interesting case within the scientific use of analytical projectors comes from social science. In 1952, the anthropologist Ray Birdwhistell invented a discipline midway between linguistics, sociology, and anthropology that he termed kinesics, aiming to systematically study all movements of the human body in a given social situation as fragments of nonverbal meaning. The proceedings of kinesics included the scrutiny of films depicting people in given settings, and analytical projectors played a crucial role in this practice.[15] A methodology for visual data collection was devised in the context of the transdisciplinary project Natural History of an Interview, started in 1955 with Birdwhistell among its members. The films to be analyzed in projection were to be first printed in working copies (to avoid physically damaging unique copies while projecting them) and, in the process of being printed, they would be superimposed with a purposefully produced B-roll consisting of an ascending frame count at one of the

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13 Defensive Behavior of a Termite (Nasutitermes exitiosus). Thomas Eisner, Irmgard Kriston and Daniel J. Aneshansley *Behavioral Ecology and Sociobiology*, 1976, Vol. 1, No. 1 (1976), p. 92

14 L-W International, n.d.

15 Leeds-Hurwitz & Kendon, pp. 156-158

corners of the film. In this way, every single frame in the analyzed film would be identifiable during its screening. The method also describes how the original raw footage is reduced to its meaningful fragments, a collaborative process involving the collective viewing of a film clip at different slow-motion speeds up to 100 times.[16]

If all scientific and educational uses of analytical projectors have been eventually substituted by digital technology, there is a field in which these machines still hold a unique value: avant-garde film. Different trends of the so-called experimental cinema are still sensitive to the artifactual, irreplaceable qualities of photochemical film and analog film projection. In this particular context, analytical projectors have played a discreet but relevant role in the creative and technical process of several film artists from the late 1960s onwards. Filmmakers like Ernie Gehr (in *Reverberation*, 1969), David Rimmer (in his earliest films, like *Surfacing on the Thames* and *Variations on a Cellophane Wrapper*, both 1970), and James Herbert (throughout most of his filmmaking career) have altered their footage both temporally and graphically by rephotographing it through the modulations allowed by an analytical projector. Still to this day, analytical projectors are part of the equipment of artists' labs and workshops focused on experimental filmmaking, such as Mono No Aware in New York City or Master LAV in Madrid. Spanish filmmaker Pablo Useros has modified Kodak Analyst changing its halogen lamp for a LED light and removing its shutter blades to use it in conjunction with a Bolex camera as an optical printer to copy his 16mm footage.

Undoubtedly the filmmaker that has most consistently explored the different possibilities of the analytical projector and has helped popularize it among the audience is Ken

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16 Leeds-Hurwitz & Kendon, pp. 169, 171

Jacobs. He first used it to produce his seminal feature film *Tom, Tom the Piper's Son* (1969-71), where he rephotographs a print of the homonymous 1905 film produced by the American Biograph and Mutoscope Company. The original 14-minute film is 'analyzed' through extensive spatial and temporal modulation for 115 minutes, using a Victor Animatograph 40[17] to freeze-frame and advance in a forward or reverse direction for a variable range of speeds and a moving camera that rephotographs the projected frame at different distances, highlighting diverse imagery and textural qualities. When Jacobs started teaching film at Binghamton University in 1972, he and filmmaker Larry Gottheim[18] used analytical projectors extensively for their film appreciation classes. They acquired several of them (at least one Kodak Analyst and four Animatograph 40) for the department throughout the decade. Hollywood filmmaker Nicholas Ray also used them in the year he taught at Binghamton while he led the students in the production of the unfinished film project *We Can't Go Home Again*.

On several dozen occasions from 1975 to 2000, Jacobs performed at least 22 iterations of what he termed the 'Nervous System,' a live projection spectacle that used two parallel analytical projectors with identical prints of the same motion picture (usually a piece of archival footage). A propeller-shaped spinning shutter was positioned in front of both projectors in such a way as to alternatively block, screen, or merge each of the projector's images. Both identical prints screen the exact moment in the film with a difference of one to three frames, maintaining that minimal difference as they slowly advance or stay still on the screen, their slight photographic difference producing an effect of three-

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17 André Habib generously shared with me part of his extensive research on Jacobs' methods for filming *Tom, Tom the Piper's Son*, as well as a 2016 email written to him by Lloyd Bruce Holman, in charge of the equipment of the Film Department at Binghamton during the 1970s.

18 Email from Larry Gottheim to the author, 2022.

dimensionality that needs no special optical equipment from part of the audience. Jacobs eventually stopped his complicated Nervous System performances and turned his performing efforts to the 'Nervous Magic Lantern,' for which he used a self-built device. Apart from written testimonies, only three of his Nervous System pieces are documented (although in a reworked form) in digital video.[19]

Annotated Bibliography

As this bibliography shows, analytical projectors are an under-researched technological topic. Most helpful information would be gathered by locating and studying the manufacturers' archives and comparing different models. Comprehensive studies about their role in (a) sports training, (b) military training, and (c) scientific research and visual analysis at large are also much needed.

André Habib is doing serious research on Ken Jacobs' use of analytical projectors, focusing on his film *Tom, Tom the Piper's Son*. He will be releasing an article about it sometime soon.

In this bibliography, I will list the two texts that have been helpful to me in writing this paper. I have also consulted dozens of scientific papers that mentioned their use of analytical projectors, located through JSTOR and Google Scholar. Further details about the models discussed here have been collected through the projector manuals I have located and through emails and conversations exchanged with Larry Gottheim, André Habib, Flo Jacobs, and Ken Jacobs.

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19 Rose, William. Annoted Filmography and Performance History. In Pierson, Michele, James, David E., & Arthur, Paul (Eds.) *Optic Antics. The Cinema of Ken Jacobs*. New York: Oxford University Press, 2011. pp. 270-272

Leeds-Hurwitz, Wendy & Kendon, Adam. The Natural History of an Interview and the microanalysis of behavior in social interaction: A critical moment in research practice. In James McElvenny & Andrea Ploder (eds.), *Holisms of communication: The early history of audio-visual sequence analysis*. Berlin: Language Science Press, 2021. pp. 145–200.

The article offers an account of the interdisciplinary research group Natural History of an Interview, which pioneered visual film analysis at the crossroads between anthropology, sociology, and experimental linguistics. It traces its history, principles, participants' biographies, and, most importantly, the methodology they devised to proceed in the audiovisual analysis of films depicting routine social interactions. As for analytical projectors, it offers a couple of revelatory details given by Ray Birdwhistell about the Bell & Howell Slow Motion Analyser (probably either a Time-and-Motion or a D5) and about the PerceptoScope, both of which he used extensively (p. 172). He compares them by favoring the PerceptoScope, which he says "has no equal as a research or exhibition device." Otherwise, no more detail is given about analytical projectors.

Wasson, Haidee. *Everyday Movies. Portable Film Projectors and the Transformation of American Culture*. Oakland: University of California Press, 2021.

Wasson's book combines sociology and thorough technical documentation to trace the interactions between film equipment and the American middle class (both in domestic and professional settings) throughout the twentieth century, focusing on post-World War II economic boom. She dedicates three pages (pp. 165-167) to 'analytic' film projectors, describing their importance to specific industries and giving descriptions for the Kodak Analyst, the PerceptoScope, and Bell & Howell's D5.