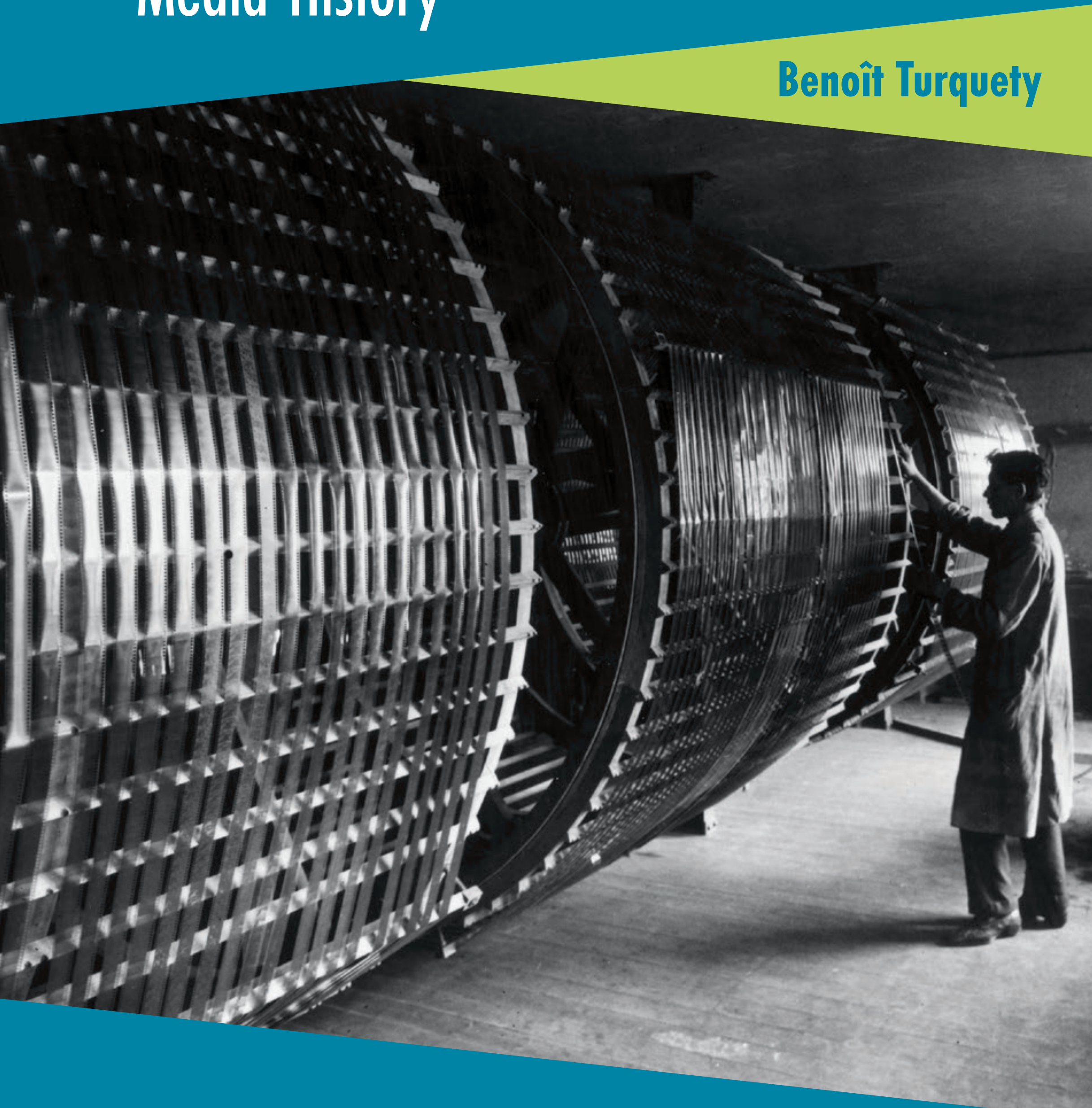
INVENTING CINEMA

Machines, Gestures and Media History

Benoît Turquety



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cinema and technology

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Cinema and Technology focuses on the emerging field of study on the history of film technology and its impact on the way the world is experienced, rationalized and apprehended. The materiality and nature of film devices, their function and use in diverse industrial, educational, and social contexts, and the integration of film technologies as an enduring element of consciousness, forms the basis of the scholarship presented in our books.

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Machines, Gestures, and Media History

Benoît Turquety

Translated by Timothy Barnard

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1. That the instruments be very accurate, so that the expense not be pointless and that there be no chance of error.
2. That their cost not be increased by superfluous adornment in order that they be used more frequently by putting them within reach of people of modest means as much as possible.
3. That their construction be the simplest, the most natural and most solid possible, in order for them to be copied or repaired at the least cost, with the least learning, and with the least level of skill.
4. That they be applicable to the greatest number of applications, when the extent of their use does not detract from their simplicity, so as not to multiply their number unnecessarily and in order to save expense and usefully and pleasingly to provide the means for varying experiments of the same kind.

– Abbé Jean Antoine Nollet, *Programme, ou Idée générale d'un cours de Physique expérimentale, avec Un Catalogue raisonné des Instrumens qui servent aux expériences*, Paris, 1738

In memoriam Jules Carpentier

For François Albera

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Acknowledgements

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Introduction: The Problems of Digital Cinema

Abstract
This introduction first describes the current situation in the cinema production industry and the discipline of film studies. Digital means involve new problems regarding remediation, perceptual specificities, the notion of reproducibility, or archival ethics. These transformations force us to rethink what the concept of invention means in media studies. In turn, this implies finding ways to analyse both machines and gestures.

Keywords: digital cinema, archival theory, technology, reproducibility, remediation, facsimile

This book materialized at a quite precise moment, albeit the periodization and determinations of this moment remain fairly difficult to specify. It lies in the midst of a period when 'cinema' is being transformed, with the gradual abandonment of its original system of analogue image and sound recording on a photo-chemical base in favour of their digital coding and storage. This evolution has not only affected cinema: it has already had an impact on music and sound recording, photography, book publishing, etc. In the case of cinema, its complexity has delayed somewhat a process that soon appeared inevitable.

This shift has shaken up every field in which cinema operates: with the creation of new professions and the transformation of existing trades; the appearance of new industries and the bankruptcy of film laboratories and motion picture camera manufacturers; companies no longer producing film stock; major transformations in the ways in which 'copies' of 'films' are distributed; profound alterations to the system's overall economy involving entirely new circulations of money; radical changes to the way moving images are consumed by viewers (on computers, mobile

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telephones, etc.); new problems for film archives; the list goes on and on. The scope of the transformations appears so great that our vocabulary no longer seems adequate to the task: can we still call cinematic works 'films' if film, meaning light-sensitive film stock, is no longer present at any point in the production, storage, or dissemination process?[1] Can we still use the term 'cinema' to name what is produced or consumed in ways seemingly so different from the traditional model – or must we speak more broadly and more vaguely of moving images, of media, of expanded cinema, of 'post-cinema'? The very essence of the medium appears to be called into question, as Francesco Casetti, for example, has summed up:

> The advent of the digital image changes cinema's relationship with physical reality. No longer, the story goes, are we dealing with an image based (as with photography on film) exclusively on a direct record of objects placed in front of the camera, the essential link between the world and its representation of things without ever having need of things themselves, thanks simply to the elaboration of an algorithm.[2]

This transition to the digital appears to have changed everything – everything except *one* thing, in fact: the viewer's experience in the movie theatre. Strangely, the 'digital revolution' is even built on a heartening assurance: for the viewer, all of this changes nothing. You will not see the difference, or hear it either. Even if you wanted to, it would not be possible. Naturally, the digital appears to bring novelties with it – so-called 3D, for example – but they already existed in 'traditional cinema' (silver gelatin, photo-chemical, analogue). As John Belton points out in an article with the explicit title 'Digital Cinema: A False Revolution': 'All that the proponents of digital projection are claiming is that it is comparable to 35mm. That does not sound like a revolutionary technology.'[3]

What, then, is happening? Is it justifiable that every movie theatre in the world has to purchase digital projectors, whose technology is doomed to obsolescence, in the short term because the standards for digital projection are not yet stable or worked out, even if it means getting rid of their 35mm projectors in (more or less) good operating order?

1 See Dan Streible, 'Moving Image History and the *F*-Word'.
2 Francesco Casetti, 'Sutured Reality: Film, from Photographic to Digital', 95.
3 John Belton, 'Digital Cinema: A False Revolution', 105.

All of these issues have had a major 'impact'[4] on film theory and film studies. In particular, they have led to the re-examination of the role of technics in the discipline. In fact, for a number of reasons, this discipline was established independently from technological questions, if not by obscuring them. Although film history was, initially and until the mid-1920s, the history of its technics, cinema's legitimation as an art went hand in hand with a downplaying of these issues as questions shifted towards the films themselves, towards movements and currents, artists and 'auteurs'. To a degree, the technical question, in some of its precise forms (depth of field in particular) returned to the theoretical forefront in the 1970s, under the impetus in particular of Jean-Louis Comolli's famous series of texts in *Cahiers du cinéma* in 1971-1972 entitled 'Technique et idéologie'.[5] Other studies followed,[6] in some cases guided by the idea that a *materialist* history of cinema could not dispense with technological issues and the analysis of determinations that guide it and that, in turn, it could influence. Quickly, however, technical questions were relegated to the background once again, with the exception of studies of historical moments of manifestly technological import, in particular the advent of the 'talking film'. But even in these cases the approach adopted was primarily economic and not especially technological.

At the same time, historical or pragmatic technological studies of cinema came to constitute a separate body of work, often carried out by people outside the university and little known to those within it.

Today, these questions are re-emerging, in tandem with transformations seen as fundamental to the system of 'cinema' as a whole, but whose place and the issues they raise are not always grasped precisely. This is due both to the fact that these changes are overwhelmingly taking place on multiple fronts and to the instability of the devices themselves. The latter's properties, forms, and functions seem almost indescribable: ephemeral 'black boxes' that are constantly being 'improved', with yesterday's obvious

4 A major conference was held in Montreal from 6 to 11 November 2011 entitled 'The Impact of Technological Innovations on the Historiography and Theory of Cinema', co-organized by André Gaudreault (Grafics/Université de Montréal) and Martin Lefebvre (Arthemis/Concordia University), under the aegis of the Permanent Seminar on Histories of Film Theories.

5 Jean-Louis Comolli, 'Technique et idéologie'. Published in translation as 'Technique and Ideology: Camera, Perspective, Depth of Field'.

6 See in particular Patrick Ogle, 'Technological and Aesthetic Influences on the Development of Deep-Focus Cinematography in the United States'; Douglas Gomery, 'The Coming of the Talkies: Invention, Innovation and Diffusion'; Edward Buscombe, 'Sound and Color'; Edward Branigan, 'Color and Cinema: Problems in the Writing of History'; and Brian Winston, 'A Whole Technology of Dyeing: A Note on Ideology and the Apparatus of the Chromatic Moving Image'.

defects or qualities suddenly disappearing or becoming *unrecognizable*. The temptation is therefore great to try to isolate, beyond these successive transitory and ill-defined incarnations, the 'essence' of these procedures and thus to bring the theoretical issues raised by such transformations (but also their perceptual and aesthetic issues) back to an overall ontological framework.

The fundamental problem in apprehending this shift from photo-chemical base to digital storage – by way of that fascinating but today often forgotten object, the analogue electronic image on magnetic tape, the *video* – is primarily methodological. It consists of constructing a possible mode for apprehending the transformations underway that would make it possible to grasp all of their aspects without reducing their complexity. One must, for example, conceive of the connections between technics and aesthetics without falling into 'technological determinism', a methodological spectre that sets out a simple and unidirectional link between device and form. Rather, this link can be found on several levels. We might ask ourselves, for example, how a filmmaker pictures and chooses his or her material, beyond or *taking into account* the often crucial economic questions. Why did Raymond Depardon shoot *Délits flagrants* and *Modern Life* in 35mm rather than in 16mm or on digital equipment? Johan van der Keuken shot *The Long Holiday* with a small digital camera rather than on 16mm and wondered explicitly, in the film itself, how that changed the shots he took, how this new form in his hand, this different weight, modified his style. In 1990, Philippe Grandrieux commissioned Robert Kramer to make a one-hour film in a single uninterrupted shot, a performance made possible by (analogue) video, something impossible with film. Kramer made *Berlin 10/90*, an extraordinary reflection on (among other things) that formal and political monstrosity known as the sequence shot.[7]

We may also ask ourselves what may change the base on which the work is viewed, and the perceptual issues raised by the technical ways in which it is viewed. Today, for example, Michael Snow and Peter Kubelka do not allow their *films* to be 'reproduced' on DVD. This does not prevent Snow from making videos or digital works, some of which explicitly address the possibilities of the new medium. **Corpus Callosum* (2002) is a case in point. But ↔ (*Back and Forth*, 1969) and *La Région centrale* (1971), made on (16mm) *film*, must be viewed only on film – even though this means that

7 On this point I take the liberty of referring the reader to my article 'Épaisseur du temps et chronographie de la terreur: *Berlin 10/90 le Temps dans le cinéma documentaire*'.

the opportunities for seeing these works, today, are singularly reduced. Snow has made some exceptions: *'Rameau's Nephew' by Diderot* (*Thanx to Dennis Young*) *by Wilma Schoen* (1974) and *Presents* (1981) were released on VHS in 2002 and then on DVD in 2012 and 2010 respectively.[8] Snow has also produced a rather incensed illustration of the reasons for his reticence: in 2003, he made a DVD from *Wavelength* (1967). This new work is a meditation on the fundamental principle of the digital: compression. The original 45-minute film was broken down into three equal 15-minute segments, scanned directly from a 16mm print without eliminating the scratches and dust on it and superimposed. The result is entitled *WVLNT*, or *WAVELENGTH For Those Who Don't Have the Time*;[9] the transition between the two media brought about a complete reconfiguration of the work's plastic and temporal densities. The compressed and digitized film is a completely different film.

This question of the transition between media has been a central topic of discussion in the film archive milieu. Restoring a film using current methods will, at one point, involve changing the base of the work, which today is often definitive. The 'original' silver gelatin print is scanned and digitally reworked; until recently, it was then copied back onto film. Today, however, it is packaged in the form of a DCP, or digital cinema package – the digital equivalent of a distribution print – and/or a DVD. What happens to the work in the course of this transition is one of the major questions confronting archivists. Here, too, the issues are many, and each is complicated by financial implications. What does it mean, ultimately, to restore a film? And what are the tasks of a film archive? All that may be recast by the digital. Giovanna Fossati, for example, explained in 2009:

> Digital projection at high resolution (the only kind of digital projection whose quality is comparable with that of film projection) is in many ways not a viable option yet, as discussed earlier. Projectors are too expensive and technology is still developing too rapidly, resulting in a lack of standardization, and, thus, in high risks.
> However, apart from technical aspects, there is another important argument for archives not to use digital projection for exhibition. If preserving films as such is one of the film archives' primary tasks, preserving the practice of film projection, and its related viewing experience, is perceived as an equally important task. For many film archivists, indeed, projecting

8 Published by Re:voir vidéo in Paris.

9 Published by Art Metropole, Toronto.

> a (digitized) film-born film through a digital projector means betraying its original form. This is no surprise since the FIAF code of ethics explicitly states that only a duplicate on film, in the original format, is to be considered a preservation master (FIAF, 1998).[10]

The situation changed drastically in 2013. Although standardization of digital projection had still not been achieved, as debate still raged between the champions of '2K' and '4K'[11] in particular, digital projection had become common enough in commercial exhibition that film archives also equipped themselves with it. Today, it is common to attend screenings of digital 'restorations' of films originally shot on film in practically every institution connected with the International Federation of Film Archives (FIAF) – sometimes without this fact ever being mentioned in the institution's programme. Several points in Fossati's above remarks could, nevertheless, be commented on, as they articulate recurring presuppositions in discussions of digital cinema. In the first paragraph she states that, under certain conditions, digital projection is of *comparable quality* to film projection. These conditions have to do above all with image resolution. Yet, such a statement supposes the existence of criteria for judging the quality of the respective systems, which would make it possible to compare them. Naturally, the very definition of *quality* in this context, and thus as a result the determination of criteria, can only be entirely ideological. A high-resolution image is of 'higher quality' than a 'low-resolution' image, just as 35mm is of 'higher quality' than 16mm or Super-8. This criterion is based on the quantity of information contained in the image, seemingly conveyed by the 'resolution' data. Four million pixels for an image is objectively more information than two million; it is thus a 'higher quality' image.

To describe phenomena in this way is already to conceive of the image as an ensemble, a system or a flow of information and to think of it in terms of transmission, mediation, and transparency rather than in terms of plasticity, depth, and form. An image conceived as an accumulation of information is already an image conceived digitally, even when it is recorded on a photo-chemical base – or painted on canvas, carved in wood, etc. Are the great and sumptuous plastic depth of the reversal 16mm stock in

10 Giovanna Fossati, *From Grain to Pixel: The Archival Life of Film in Transition*, 99-100.

11 '2K' is the term for an image with 2048 pixels (a standard adopted for 'digital cinema' or D-Cinema, as specified in 2005 by the Digital Cinema Initiatives [DCI]). A '4K' image has 4096 pixels.

Jonas Mekas's *Notes on the Circus* (1966), the materiality of its contrasts and superimpositions, the specific granularity of its soft-focus and pulsation, the density of its blacks and the iridescence of its reds, of lesser 'quality' than the perfect and no less splendid 35mm VistaVision Technicolor print of *The Searchers*, lit by Winton C. Hoch for John Ford in 1956? Is the amateur 'DV' digital format used by Pedro Costa for *Juventude em marcha* (2006) of lesser 'quality' than the 'HD' used by Michael Mann for *Collateral* (2004)? And what would that mean?

Making these sorts of comparisons between film and digital involves another supposition: recognizing a kind of equivalency between the *grain* of the emulsion and the *pixels* found in digital images. Once this equivalency has been made – and Fossati's book is entirely based on such a thing, as the title itself indicates: *From Grain to Pixel* – such a comparison becomes possible and quantifiable. And yet, it is a dubious comparison, on several levels. On the technical-perceptual level, firstly, as has been explained many times in lectures by Jean-Pierre Beauviala, an engineer, inventor, and head of the Aäton company. The pixels in a digital image form a fixed matrix, an underlying grid that cannot change from image to image, whereas the random position of grain in each silver-gelatin film frame produces a sharp focus and a shifting materiality completely unlike the image definition found in a digital image. This comparison, moreover, is not neutral on the theoretical level, as it supposes the divisibility of the photographic image into 'picture elements', placing the analogue image into the framework through which we understand the digital.

The next part of Fossati's argument has to do with the 'betrayal of a film's original form' potentially involved in the transition between media. On this topic, in a documentary made in 1996-1997, Stan Brakhage declared:

> One of the major things in film is that you have 24 beats in the second, or 16 or whatever the projector's running at. You're in a medium that has a base beat that's intrinsically baroque. And aesthetically speaking it's just appalling to me to try to watch, for example, as I did, Eisenstein's *Battleship Potemkin* on video. I mean, it dulls all the *rrrrip!* of the edit. And because video looks – in comparison to the sharp, hard clarities of snapping individual frames, and what that produces at the cut, video looks like a pudding that's virtually uncuttable, like a gel, a jello, it's all ashake with itself.[12]

12 Colin Still, *Brakhage on Brakhage*, 1996-1997.

Thinking about the shift from one base to another should be seen in light of the question of the 'facsimile', as Erwin Panofsky developed the idea in 1930:

> I wish and hope that we will learn to improve and will continue to make 'better' facsimile reproductions. It is because of these advances, not in spite of them, that we will be increasingly adept at distinguishing the original from its facsimile reproduction. Furthermore, it is because of these advances, and not despite them, that we will increasingly regard facsimile reproductions with benefit and even enjoyment.[13]

A film seen on video is a facsimile of the original. It transmits a certain quantity of the original's 'information' or characteristics, while other information or characteristics disappear or are transformed. In any event, it can only be seen as a facsimile.[14] What remains, as Panofsky remarks,[15] is to evaluate the nature and degree of the transformations for each work according to the degree of the form's dependence on the material in which it is bound up. This question of the relations between form and medium was in play before the digital, whether with respect to the dissemination of works in general, or more precisely with respect to archives. To make, show, and preserve on 'safety stock' (film made out of cellulose acetate) an original 'nitrate' film ('flam' film, made out of nitrocellulose) is already to make a facsimile: the base has changed and the work's visual (and aural) properties with it. This can be accompanied by other transformations with varying degrees of importance: from an orthochromatic emulsion to a panchromatic one; from an original in colour to a black-and-white copy; from a varying projection speed, from about 18 to 20 frames per second, to a standardized 'talking film' speed of 24 frames per second; from one aspect ratio to another; from one audio system to another; etc. The indisputable underestimation in the history of film theory of the perceptual variations brought about by changes in the base is undoubtedly the result of complexly intertwined factors. According to Paolo Cherchi Usai, we should, on the one hand, see in this a limited attention to the 'content' of the image, and on the other a conceptual framework defined by 'a superficial reading of Walter

13 Erwin Panofsky, 'Original and Facsimile Reproduction', 337.
14 On this question and some of its implications for film studies, see the Society for Cinema Studies Task Force on Film Integrity (headed by John Belton), 'Statement on the Use of Video in the Classroom', 3-6.
15 Erwin Panofsky, 'Original and Facsimile Reproduction', 54.

Benjamin's canonical essay "Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit".'[16]

FIAF's code of ethics, quoted by Fossati, states that 'within the technical possibilities available, new preservation copies shall be an accurate replica of the source material.'[17] A statement such as this leaves open a wide margin for necessarily ideological interpretation (the 'accuracy' of the 'replica') and for pragmatic relativism by acknowledging constraints, including financial ('within the technical possibilities'). What the digital has transformed is the breadth of this margin, to the point of changing the status of the questions themselves. The problems associated with the facsimile, as well as the possibilities for altering a film's form while restoring it, were already present in the 'photo-chemical era', but not in the same proportions. From photo-chemical to digital, what has changed is not really the operations undertaken but their relations, their relative weight, the proportion of each when they interact. But this shift in proportions is so great that it has forced us to re-examine the precise nature of the operations. Thus, for example, the digital may establish a radical difference between the base of a preservation copy of a film made on film (a duplicate 35mm film preserving the same speed and in the same aspect ratio as the original) and that of the copy made for exhibition (a DCP copy whose projection speed may have been modified). And yet, the digital may make it possible to render the original's *appearance* in a way that would be difficult to achieve (for strictly technical or economic reasons) by photo-chemical means alone. This is striking in the case of the first 'natural colour' film processes, such as Kinemacolor, which will be discussed below, Chronochrome, etc. These additive processes require specific projection systems to achieve their colour synthesis; because the original projection conditions are, in concrete terms, practically impossible to recreate, the possibilities afforded by the digital for the treatment of colour have made it possible to achieve a *simulation* of the process that is certainly closer to the original on numerous points. We thus find an intriguing clash between the *look* of a procedure and the medium, and this is a clash on which archivists must take a position. Fossati, for example, clearly positions herself on the side of simulation: 'I argue that maintaining the original film's look is more important than remaining true to the original format.'[18] Naturally, the emphasis on appearance can only be understood on the basis of concrete familiarity with what each procedure could look

16 Paolo Cherchi Usai, 'La Conservation des images en mouvement', 13-14.

17 'FIAF Code of Ethics', http://www.fiafnet.org/pages/Community/Code-Of-Ethics.html.

18 Giovanna Fossati, *From Grain to Pixel*, 71.

like – with what it could be theoretically, but also with what it could be in concrete terms, in the precise technical (and cultural and social) context in which it was first experienced or shown: the projectors; mechanisms; lamps (the colour temperature, intensity, and throw of the light); screens; emulsions; factors involved in enlarging the image; lighting in the theatre; kinds of images and thus the kinds of film, etc. This therefore involves close familiarity with cinema's technics – requiring in particular that film archives, as part of their work, preserve projection practices for every film format – along with familiarity with the visual experience connected with them each time.

Thus, to understand the problems connected with cinema's shift to the digital we must situate this moment in historical perspective in order to gauge precisely its unprecedented nature. More particularly, therefore, we must elaborate or re-elaborate, in light of the issues that have recently emerged, the means of and questions raised by a technological history of cinema. We must produce tools that will make it possible to grasp this transformation in all its forms, whether having to do with the practices of viewers, film archives, or those working in film production; with film theory; with economics; with commercial, amateur or experimental cinema; with aesthetic forms and issues; etc.

To this end, in the present volume I propose to examine a few historically exemplary machines, whether or not they are recognized as such by film historiography, and, more broadly, other kinds of viewing *dispositifs* and procedures: the Wheatstone stereoscope; the Lumière Cinématographe, Urban-Smith Kinemacolor, etc. These machines could be projects that never came to completion, or whose fundamental technical principles were merely formulated by their authors, as we will see with the devices imagined by Louis Ducos du Hauron and Charles Cros in the 1860s. Alongside these, we will look at the evolution of a few precise technical elements of viewing machines: viewfinders, cranks, etc.

For a variety of pragmatic and theoretical reasons, I have been obliged to abandon, temporarily, the idea of exploring specifically sound-related questions, despite or rather because of their formidable nature. The objects I examine have brought about this focus on visual elements, which has the advantage of making it possible to enter into detail when discussing them. This also demonstrates that it is indeed from within a history of optical phenomena, seen as consistent and generally autonomous, that certain problems associated with 'cinema' were worked out. On the other hand, this approach has the regrettable defect of making us underestimate the fundamental cultural and epistemological issues around the links between our eyes and ears – between the eye and the body – as they were imagined in the history of science and the history of the arts. Audio and audiovisual questions cannot be underestimated; addressing them will intersect with, amplify, or render more complex what I have been able to do here.

This analysis will make it possible to interrogate what, *technologically*, cinema is – or, rather, how a technological description of cinema should be articulated – as well as the tasks, forms, and means of a history of cinema's technics, or a history of its machines. What are we looking for, what means do we have, what can we expect to find in constructing a history of machines?

To clarify the present moment, that of the transition to digital procedures, this study will focus on the question of invention. Under what conditions can a particular machine be seen as an invention, with all that that supposes in the way of novelty and rupture? The notion of invention, along with the rival notion of innovation, is of interest in that it is immediately historical. It involves studying the machine in the conditions of both its genesis and its reception by a given culture at a given moment. Moreover, it also brings into play a precise conception of history, one which admits as central the possibility of discontinuities in historical movement and that of identifiable ruptures, points of retrogression or moments of upheaval. Acknowledging, as Georges Canguilhem remarks, that 'the complacency of seeking, finding and celebrating precursors is the clearest sign of ineptitude in epistemological criticism,'[19] will lead us to make clear and to understand exactly the breaks and continuities in each machine, in each 'invention', whether imagined or real.

The framework of this endeavour will thus impose a methodology to connect machines and history, to connect an invention with the historical context that enabled its conception, on the one hand, and, on the other, its possible dissemination in society. This book will place a technological analysis of machines alongside a history of technics, an archaeology, and an epistemology.

The former will place devices in their surrounding technical context, which includes both other, pre-existing devices in the same domain or in more or less related domains, on the one hand, and the full range, in a broader sense, of the strictly technical or cultural uses and practices tied to them. In the case of the earliest kinematography devices, this could be the practices or technical conditions of photography at the time (the gestures associated with it, its social uses, its economy), but also mechanics, the

19 Georges Canguilhem, 'L'Objet de l'histoire des sciences', 21.

spread of the sewing machine, the place of kinematics as a discipline in education, changes to the organization of labour in industry, etc.

The archaeology proceeds from the machines to a general history: it takes up the devices as archives of the gestures, operations, and conceptions they objectify. The structure, form, and logic of the machines are the materialization of the operative series that produced them, while also bearing witness to the gestures they replaced or took part in. The machine traces the organized series of gestures that make up the way it is handled, according to which it was conceived, and which, in part, it determines in return. At the same time, each media machine is also the archive of a certain mode of perception. Seeing a film shot by Alexandre Promio with a Lumière Cinématographe is a specific visual experience, one completely different from that produced by watching *With Our King and Queen through India* (1912) on a Kinemacolor projector, and different yet again from viewing a film made by the Skladanowsky brothers with their Bioskop, or from watching the same picture by Promio in one of the 'windows' of the computer screen on which this text is being written. The archaeology of machines will thus make it possible to use devices to create a history of modes of perception, performance, and production.

The epistemology of machines attempts to understand, through the analysis of the objects and their genesis, the epistemological conditions of their conception and the 'implicit conceptual structures' that they put into play. In order to understand a machine in the precise manner in which it was conceived, one needs an idea of what it should be, what it should do, and the best way it can accomplish this task. One needs a sense of its place in the collective imagination and a conceptual framework in which the machine had a role and found the function sought for it. This framework is structured by a constellation of concepts that interact according to a singular configuration; inventors, engineers, users, etc. do not have a systematic awareness of this constellation because it is not always formulated and put into words. In fact, this conceptual framework can never be fully formulated, because the nature of technics situates it, as we shall see, on the side of the synthetic and not of the analytic – on the side of the non-verbal and of gestural or figural transmission rather than discursive explanation. This is the result of the fundamental affinity between machines and images, or more precisely between machines, images, and movement, which can be seen in the historical role granted to machines in our culture. The epistemology of machines thus aims to formulate, at least in part, this 'implicit conceptual structure' and thereby, on the basis of each individual object, to reconstruct the epistemological framework of the machine and of 'cinema' at that moment.

In this I will make central use of the concept of the *problem*, as it has been developed in particular by Gaston Bachelard, Georges Canguilhem, and later Gilbert Simondon. While invention is, as Simondon remarks and as will be discussed below, in the first place a 'resolution of a problem', what constitutes the foundation of the technician's work is *the way in which the problem is posed*. This will determine in part the precise organization of the technician's machine. The problem is not an abstract idea; it is a working tool for the technician whose coherence forms a system with the epistemological context in which it was conceived. Each machine is structured by the precise problem it is supposed to resolve, and the precise form of this problem, when recreated, can enable us to understand the way in which the object was viewed, and thus the conceptual framework of its emergence and the way it was seen in the collective imagination. Louis Lumière's problem was not that of Étienne-Jules Marey, Thomas A. Edison, or William K.L. Dickson. The problems being posed today, or which present themselves to the engineers of the RED Digital Cinema company are not those posed by the ARRI company: they do not all seek exactly the same thing, nor do they apply themselves to exactly the same difficulties. They rank their priorities differently and, as a result, develop machines whose logic is not the same.

By analysing problems we will be able to understand properly the technical organization of machines and the epistemological implications of this organization. The present volume invites readers to consider a history of problems – a history of the problem 'cinema' and the singular problems that it comprises and redirect it anew each time – through the technological study of inventions. This, the author hopes, will make it possible to set out the elements of a position on the 'digital cinema' problem and the historical issues around its possible description as an 'invention'.

1. The Why and How of Machines

Abstract
This chapter first establishes the fundamental definitions necessary to the construction of the approach: technique and technology, machine and dispositif. It discusses Foucault, Simondon, Crary, and Albera/Tortajada in the process. It then argues that there is a fundamental link between machines, images, and movement within the history of culture. It analyses the apparatuses invented by Filippo Brunelleschi during the Renaissance, before exploring the depiction of machines from the Renaissance to industrial drawing. Given these relations, this chapter argues that machines should be considered as archives, materializing the history of performance gestures, and of the system they have been a part of. A detailed analysis of the camera obscura and its historical variants, connecting the histories of art, of spectacles and of science, exemplifies the approach.

Keywords: Machine, technology, dispositif, Gilbert Simondon, camera obscura, media epistemology

Today's proliferation of media, their base and equipment, has given urgency to the need to theorize the issues they raise and, consequently, have brought about the return to film theory and to media theory more generally of a vocabulary borrowed from a description of what Gilbert Simondon called 'technical objects':[1] devices; instruments; machines; technologies; techniques; *dispositifs*. Because of the structural importance of these terms to the approach taken in this volume, it is important that we establish distinctions between them.

1 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, passim.

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A Few Definitions

Technique/Technology

Historically, 'technology' is a term initially used to describe a field of study that began in English- and German-speaking milieux, first by Christian Wolff in 1728 in his *Preliminary Discoujrse on Philosophy in General*, in which he invented the concept in its modern sense. His work had no concrete consequences, but was adopted more successfully as a simultaneously theoretical and pedagogical project by Johann Beckmann in 1772 and then in 1776 in the latter's *Anleitung zur Technologie*.[2] Traces of it can be found in English in Jacob Bigelow's *Elements of Technology* of 1829. The goal of *technology* was to describe, classify, and analyse the technical operations of the mechanical arts, or 'the science of the arts and of the works of art,'[3] in the words of Christian Wolff.

The discipline itself was rarely the subject of study: it was only at a seminar led by Georges Canguilhem at the Institut d'histoire des sciences from 1963 to 1965 that a systematic history of the 'beginnings of technology' was carried out. By this was meant 'the establishment of the discourse on technical operations as a scientific discourse.'[4] The authors of the published version of this collective endeavour, Jacques Guillerme and Jan Sebestik, nevertheless stated from the outset that this 'history of *méta-technie* implies a history of *technie* itself.'[5]

Today, English, and other languages in its wake, tends to ignore this distinction, describing technology not as connected to a discourse on technical matters, to the 'logos' – a meaning described as 'now archaic' in a recent essay by Leo Marx in the journal *Technology and Culture*[6] – but rather as 'the range of technical activities founded on the application of the sciences to industrial procedures,'[7] in Guillerme and Sebestik's summary, or as 'the mechanical arts collectively,'[8] in the words of Leo Marx in the

2 Johann Beckmann, *Anleitung zur Technologie oder zur Kenntniß der Handwerke*.

3 Christian Wolff, *Preliminary Discourse on Philosophy in General*, § 71, p. 38. Wolff adds that technology should 'give the reason for the rules of art and of the works produced by art,' ibid.

4 Jacques Guillerme and Jan Sebestik, 'Les Commencements de la technologie', 1.

5 Ibid.

6 Leo Marx, '*Technology*: The Emergence of a Hazardous Concept', 562. This article takes account of no non-English-language contribution in its discussion, particularly that of Jacques Guillerme and Jan Sebestik, which is much more complete, although much older.

7 Jacques Guillerme and Jan Sebestik, 'Les Commencements de la technologie', 42.

8 Leo Marx, '*Technology*', 562. Eric Schatzberg, in '*Technik* Comes to America: Changing Meanings of *Technology* before 1930', describes 'the current characterization of *technology* as the

essay referenced above. To return to the field of film studies, in an article entitled 'Toward a Theory of the History of Representational Technologies', published in the journal *Iris* in 1984, Rick Altman noted the need to maintain the distinction, often done away with (particularly, in Altman's view, by Jean-Louis Comolli), between 'technique' and 'technology'. He does not really define these terms in his text, appearing to take their meaning as self-evident, but it seems that 'technologies' for him refers to machines as a whole and 'techniques' as the range of procedures adopted by those who operate them. He remarks:

> Just as technology often automatizes an accepted technique, so new techniques often appear in reaction to – indeed in compensation for – the introduction of the technologies [...]. The important thing to remember is that a dialectical understanding of history is destroyed from the start by any theory which reduces to one those practices that interact as two.[9]

Yet, if the history of techniques truly distinguishes procedures from objects, it remains the case that it views their history as shared, seeing them as impossible to disentangle: the history of the methods of '"workers" in flesh and blood – or rather made of wood and metal: men, or machines,' as Lucien Febvre wrote.[10] It is possible, on the other hand, that Altman's remarks still hold true in seeing a dialectic between techniques and technologies as practices and discourses on practices. Adopting one meaning or the other of the word 'technology' thus alters the questions raised considerably, because a 'technological innovation', in the sense of Beckmann or Canguilhem, describes a transformation in the field of *discourses* on techniques, and thus appertains automatically and immediately to theory or historiography. On the other hand, technical evolution in the proper sense of the adjective has a particular status and, because of its essentially non-verbal nature, poses specific methodological problems.

In France, André Leroi-Gourhan is a fundamental figure in the renewal of the interest in technology and of the methods and issues associated with it. In 1936, he published one of his first major texts, 'L'Homme et la nature: Essai de Technologie comparée',[11] in volume seven of the *Encyclopédie française*

methods and material equipment of the practical arts' (page 490), a meaning whose dominance in English he traces back to the 1930s, in the wake of the work of Thorstein Veblen.

9 Rick Altman, 'Toward a Theory of the History of Representational Technologies', 115.

10 Lucien Febvre, 'Réflexions sur l'histoire des techniques', 531.

11 André Leroi-Gourhan, 'L'Homme et la nature' 7, no. 10, 3-16 and 7, no. 12, 1-4. See Sophie A. de Beaune, 'La Genèse de la technologie comparée chez André Leroi-Gourhan'.

edited by Lucien Febvre. There, he proposed the new method 'comparative technology', or the study of the tools and modes of making in different cultures. It is from within this context, at the heart of this conception of technology, that Georges Friedmann has posed the problems of a sociology of labour. Because 'all labour depends on technical conditions,' Friedmann argued in a 1961 article in *Les Annales* that 'the study of the instruments and devices which make up the workstation is technology. The sociology of labour thus has necessary connections with it.' He added that 'the goal of technology is to study, in tandem, *the instrument and the way it is used*. Technology is thus, or should be, seen in the fullness of its vocation, as a social science.'[12]

At no time can technology distinguish technical objects from their users' procedures, for while the objects determine the users' gestures, their practices have also structured the tools – in their form, but also, perhaps, in the internal logic of the way they function. I will thus adhere to this definition of *technology* as the study of techniques, with the latter covering both machines and procedures.

Machines/Dispositifs

In his 1968-1969 course on 'the invention and development of techniques', Gilbert Simondon returned to the problem of technological classification. He proposed to distinguish, firstly, between the *tool* and the *instrument*, in that the 'instrument equips the sensorial system, it serves to provide information, while the tool serves to carry out an action.'[13] The tool extends the effecting organs the way the instrument extends the sensory organs. The distinction was, however, rendered more complex: 'the contrast between the tool and the instrument is neither absolute nor radical in its elementary forms: a rod can be used to strike or to dig, but also to prod, to sound or to explore.' We can thus imagine a tool as an instrument, even if 'through their improvement tools and instruments separate out into pure captors and pure effectors. One cannot employ a microscope as a tool without damaging it.'[14] The tool/instrument distinction is only partially inscribed in the structure of objects; it is determined in part by their use, which can suddenly decide on a change of category.

At a higher level of complexity are found *utensils* and *devices*, which form a 'third kind of *dispositif* [...] capable of functioning alone, independently

12 Georges Friedmann, 'Sciences sociales et sociologie du travail', 478. Emphasis in the original.

13 Gilbert Simondon, *L'Invention dans les techniques*, 88.

14 Ibid., 89.

of the human organism.'[15] Utensils and devices are no longer extensions of the operator, but are characterized by the autonomy of their energy. Under Simondon's classification, they constitute the central point of the technical object, which carries out the mediation of energy and sometimes of information. Here, the machine is defined as the way these three poles are arranged in relation to each other:

> The perfect machine can be seen as the result of a triadic joining of an instrument (the information or programme source), a tool (the effecter which produces labour) and finally a utensil or device, producing or capturing energy. This energy is modulated by the entry of information (instrument) directing its use in the effecter's tool, which comes out of the machine.[16]

Simondon's classification system is situated within the narrow framework of the analysis of technical objects. It could be completed and perhaps contradicted by other classifications: there were, for example, many attempts at a taxonomy of machines throughout the nineteenth century in particular. One of these typologies is interesting: that proposed by Jacques Lafitte in his *Réflexions sur la science des machines* in 1932. Lafitte distinguishes three kinds of machines according to the degree of complexity, not strictly of their internal organization, but rather of their relations with their milieu: reflex machines; active machines; and passive machines. The difference between the two initial and more complex categories has to do with the ability of reflex machines to 'modify [their] operation according to variations they perceive in their relations with their milieu.'[17] Passive machines, for their part, are fixed and immobile: 'properly speaking, they do not operate.'[18] Poles, beams, buoys, rafts, 'like most architectural constructions as well,'[19] are passive machines. For Lafitte they truly are, however, machines.

This idea is interesting for several reasons. Firstly, it makes it possible to think of an object as simple as a pole according to technical criteria – height versus circumference, rigidity, solidity, play, etc. – and a particular idea of how it operates. In addition, from a theoretical perspective, it makes it possible to separate the idea of a machine from that of a technical object

15 Ibid., 94.
16 Ibid., 95.
17 Jacques Lafitte, *Réflexions sur la science des machines*, 69.
18 Ibid., 70.
19 Ibid.

made up of mechanisms in the strict sense of the term. An object can be devoid of mechanisms (gears, valves, cams, levers, etc.) and may even be completely simple, and yet still be a machine in that it is conceived in terms of its operation, functions, reactions, and systems of interaction between incoming information and outgoing action.

It is well known that Michel Foucault, in *Discipline and Punish,* considered Jeremy Bentham's Panopticon an exemplary *dispositif.* This specific architectural construction, which could serve as a prison, but also as a hospital or a school, was based on the contraposition between a central tower, from which one can see without being seen, and a peripheral ring building made up of cells without communication between them but completely and totally visible from the tower. This 'architectural figure' was a '*dispositif*' that enabled Foucault to construct this concept and the methodology of his analysis: a 'concerted distribution of bodies, surfaces, lights, gazes' that 'automatizes and disindividualizes power.'[20] But, for Foucault, the Panopticon was also a 'machine':

> The Panopticon is a machine for disassociating the see/being seen dyad [...]. [It is] an arrangement whose internal mechanisms produce the relation in which individuals are caught up [...]. There is a machinery that assures dissymmetry, disequilibrium, difference [...]. Any individual, taken almost at random, can operate the machine [...]. The Panopticon is a marvellous machine which, whatever use one may wish to put it to, produces homogeneous effects of power. A real subjection is born mechanically from a fictitious relation.[21]

The Panopticon is a *dispositif* because it is a machine: it functions, it manufactures, it mechanically links causes and effects. The fact that it may be architectural and fixed, that its material may be individuals or desires, does not change the fact that a *dispositif* is, all the same, a set-up made out of mechanisms and that it *produces*. A *dispositif* is thus a machine in that it is *transformed by an intention*.

In several important articles, François Albera and Maria Tortajada, basing themselves in part on Foucault, have developed an application of the concept '*dispositif*' more specifically aimed at cinema and media.[22] Here, they revisit

20 Michel Foucault, *Discipline and Punish: The Birth of the Prison*, 202.

21 Ibid., 201-202.

22 François Albera and Maria Tortajada, 'L'Épistémè "1900"', 45-62; 'Prolégomènes à une critique des "Télé-dispositifs"', 35-56; and 'The Dispositive Does Not Exist!', 21-44.

definitions of the concept: 'The most common definition refers to "the way in which the organs of a device are placed" (circa 1860), soon supplemented by another meaning, that of sets of mechanical elements combined *with a view to an effect*, a result (Littré, 1874)'.[23]

Thus, a principle of placement and the 'the pursuit of an effect'[24] give the term *dispositif* a specific meaning in the technical vocabulary. Albera and Tortajada then distinguish several 'technical levels' of the *dispositif* in the sense in which they understand the term:

> 1. the *dispositifs* internal to the machine, a number of mechanisms operating with their own coherence; and 2. the machine itself, or the device, as an assembly of various clusters of mechanisms, of different internal *dispositifs*. [3. the external *dispositif*] the new disposition in which the device or the machine as *dispositifs* find their place, a disposition determined by a finality and a practice, and in which users, like the machines, are themselves elements.[25]

In connection with these definitions – those given here do not pretend to be exhaustive: Albera and Tortajada identify five levels, five definitions – the authors propose a programme of an 'epistemology of *dispositifs*', itself enacted on three levels of approach and 'three types of notions calling for explanation': the '*concrete elements of the dispositif*' and the concepts immediately associated with them (in the case of cinema, the 'film frame', 'the film's advancement through the camera', 'projection', etc.); the *abstract notions associated with the dispositif or with the concrete elements constituting it* ('series', 'synthesis of movement', etc.); and '*key notions* or *type-notions*' ('authenticity' in the case of cinema for example).[26]

The concept *machine* privileged by the present volume has a clear connection with this concept *dispositif* and the programme of this epistemology. The distinction between a machine and a *dispositif* is not always clear or easy to establish or maintain. As we have seen, in Simondon, a *dispositif* can come into play in a context in which he explains what a machine is, and 'machine' also describes Foucault's *dispositif.* Albera and Tortajada, explaining their elaboration of the *dispositif*, employ the terms 'machination' and '*machinatio*',

23 François Albera and Maria Tortajada, 'The Dispositive Does Not Exist!', 21.

24 Ibid.

25 Ibid., 22-23. (Translation modified – Trans.)

26 Ibid., 33-34. (Translation modified – Trans.)

'an ingenious disposition or mechanism in its original sense [...]. Similarly, the words "*machine*" and "*machiner*" ("to arrange") are used in French about a painting or a narrative composed with a given effect in mind.'[27]

For our purposes in the present volume, I will nevertheless separate *machines* and *dispositifs*, the epistemology of machines (about which I will return below) and the epistemology of *dispositifs*, even though the latter certainly remain the overall framework in which this book is situated. Generally, I will retain the term '*dispositif*' to describe a technical ensemble conceived *according to its intention or within a system in which it interacts directly with a user-operator* (a scientific experimenter, a cinematographer-photographer, a viewer, etc.). But here I wish to see media devices as *machines* before seeing them as *dispositifs*. It will be a matter of enquiring into their internal organization, their operating logic, how their relation to the operator has been conceived, and how this is enacted given the form of the machine, etc. Interaction with the user is not ruled out of this volume's field of research, which would be absurd, but this interaction is primarily approached on the technical, mechanical, and concrete levels before being examined on the level of the expected result (of the entertainment in question) and the cultural and other issues around it. A machine is always a *dispositif*, but examining it as a machine makes it possible to isolate its singular properties apart from the field of spectatorship as it is culturally constructed and theoretically institutionalized – even though these properties are certainly not unaffected by the underlying spectatorial experience.

To view the Panopticon as a machine is to enquire, for example, into the precise concrete conditions of its operation: the exact shape of its windows; the thickness of the walls; the distance from the central tower to the peripheral ring; the manner of lighting (beginning in 1800 and then as these techniques evolved); how the necessary bodily movements were managed (in addition, for example, to those associated with hygiene) in this necessarily static layout; how listening was organized in this *dispositif* conceived of visually; the shape of the furniture in the cells to as not to create 'blind spots', etc. To write the history of the Panopticon as a machine would be to contrast Bentham's project or idea with his practical achievements, to contrast the original plan to the real plans of institutions based on the principle, to study their construction and evolution – to no longer see variations as insignificant deviations from a fundamental principle but as a technical line of machines each with its own organization and coherence, conceived according to precise goals and a precise envisioning

27 Ibid., 23-24.

of these goals and the means to achieve them, which, in return, can have epistemological implications with respect to the *dispositif* as it was caught up concretely in systems of ideas determined historically (meaning socially, politically, economically, and technically).

In a manner clearly similar to that of Foucault, Jonathan Crary has described the *camera obscura* as a '*dispositif*'. Emphasizing the fundamental multiplicity of the uses of this device, and remarking that 'the camera obscura underwent continual modification'[28] during the period he discusses (the seventeenth and eighteenth centuries), his principal focus is its role as epistemological model, as 'the compulsory site from which vision can be conceived or represented'. From this perspective, in his view,

> Above all it indicates the appearance of a new model of subjectivity, the hegemony of a new subject-effect. First of all, the camera obscura performs an operation of individuating; that is, it necessarily defines an observer as isolated, enclosed, and autonomous within its dark confines.[29]

But the camera obscura in the period he examines was, by then, only rarely a 'dark chamber': for many, it had become portable and (relatively) miniaturized boxes instead of chambers no longer concretely isolating the observer within dark confines. Can our conclusions thus still be the same? Must we think that the *abstract principle* of the camera obscura extends beyond its concrete technical incarnations, that this evolution of the camera obscura *machine* could have no epistemological implications, even if it brought about major ruptures at one and the same time in the forms, uses, and costs of the devices, along with the kinds of images they produce, the social classes with access to it, etc.?

The objects and projects discussed in the present volume will thus be examined in the first place as machines, as historically elaborated and concrete material fixtures. The concept of the machine will not be taken as describing a particular category of technical object, but rather as describing technical objects apprehended in a certain manner. To view a technical object as a machine is to see it in terms of its operation, form, and internal organization, involving in its singular logic not only a general abstract principle, but also every concrete detail that ensures its cohesion, properties (technical, economic, aesthetic), and singularity.

28 Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century*, 30.
29 Ibid., 38-39.

To speak of machines is also to be a part of a long line of technological and theoretical thought and to think about *dispositifs* within a certain history of techniques and ideas.

Machines, Images, Movement

The Machines of Filippo Brunelleschi

In an article from 1953 entitled 'Techniques et arts', the art historian Pierre Francastel revisited that crucial moment, commented on and examined many times over: the Renaissance. He revisited it to emphasize one point in particular: the importance for the Quattrocento of a few 'discoveries of a technical nature which seem to me to be major and which may be little known. We often seem in particular to forget the quite exceptional role played by Brunelleschi.'[30] For Francastel, Filippo Brunelleschi's importance should not be gauged by his work as an architect and designer of some of the most beautiful buildings of his day, but rather as an inventor. As the inventor of a new architectural technique for the copula of the Santa Maria del Flore cathedral in Florence, which is 'not simply a larger copula than the others; it is a copula which was made differently from every copula made until then':

> It is fundamentally different for a precise technical reason: a method, discovered by Brunelleschi, for constructing a copula directly in open space, without support [...]. Here we have a true case of a technical invention which brings with it a considerable series of aesthetic possibilities.[31]

Other feats were connected to this major development, which 'enables us to say that there truly was at that time a correlation between art and technical novelties.'[32] Brunelleschi was also a part of the 'discovery of perspective, about which there is too much to be said, but which was not at all the discovery of a rational means to depict the world as it is on a two-dimensional surface. It was an arbitrary and artificial construction; a montage, a system [...].'[33]

30 Pierre Francastel, 'Techniques et arts'. Reprinted in Francastel, *L'Image, la vision et l'imagination: L'objet filmique et l'objet plastique*, 156.

31 Ibid., 156.

32 Ibid., 160.

33 Ibid., 159.

This, decidedly, was not negligible. But, Francastel argues, there is more, for 'through Brunelleschi, a third original invention appeared at the beginning of the Quattrocento':

> I think of Brunelleschi the inventor of machines. Everyone knows that he was initially the inventor of a small optical instrument consisting of a kind of box. It had a panel on which a picture of Florence was painted. One placed one's eye at the centre of this panel; there was a mirror at the other end, and a mirror below to reflect the sky. When you looked through the little hole, you saw reflected, in all its relief, the picture painted on the panel. This, moreover, was one of the sources of the Renaissance's so-called realist perspective. But there was something more about Brunelleschi. In particular, a whole project involving the fabrication of machines, something also described in the forgotten texts by Vasari. Nevertheless, they make it possible to establish that the Quattrocento, the Renaissance, constructed a whole series of machines for countless spectacles of public life. All this activity prepared the evolution of theatre [...]. It enabled humankind to visualise, in a moving, living and changing manner, a whole series of myths and legends taken either from tradition or from the imagination of people of the day.[34]

This passage mixes several elements in a rather complex manner. In it, Francastel classifies as a 'machine' – and foremost among them – this *dispositif* invented by the Florentine architect Brunelleschi, which was recognized at the time as a real-life demonstration of linear perspective. Thus, of all the machines of which Brunelleschi was effectively the inventor – winches, cranes, etc. – Francastel chose as an example what he views as the prototype of the 'optical box' – boxes that truly began to circulate only in the mid-seventeenth century – which he associates with other kinds of more theatrical machinery within a vast ensemble he calls 'spectacles of public life'. These machines are thereby immediately tied to 'moving', 'living', and 'changing' visualization – three adjectives were indeed necessary.

Yet, Brunelleschi's 'machine', the 'founding myth' of perspective, albeit one never mentioned in histories of so-called pre-cinema, was not a box but a set of two moving panels (Illus. 1). One was painted and had a hole in it, the other was a hand mirror. On the painted panel was depicted,

34 Ibid., 159-160.

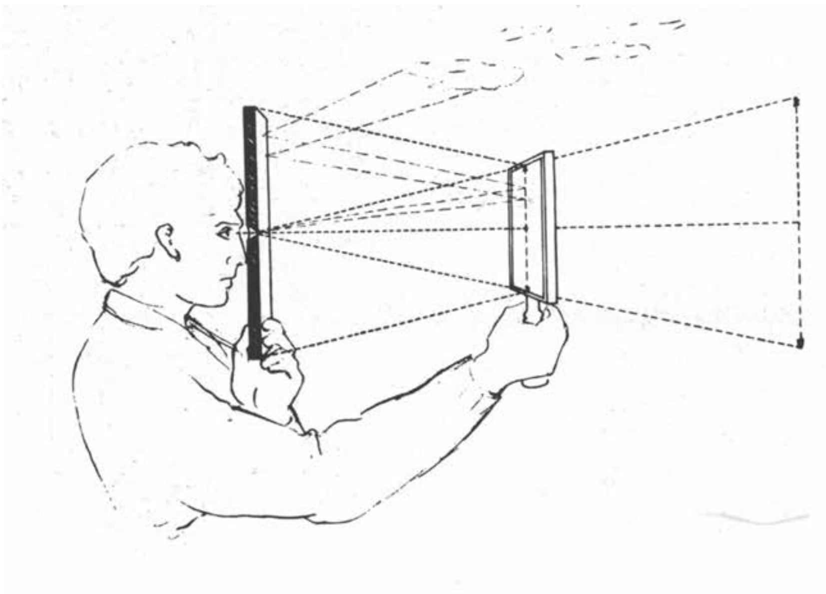

Illustration 1 – The 'invention' of perspective: Filippo Brunelleschi's device, 1425.

more precisely than a picture of Florence, a perspectival image of the San Giovanni baptistery, seen from a point a few metres from the entrance to the Santa Maria del Flore cathedral. If a kindly viewer were to take up position at this spot and place his or her eye behind the hole in the panel, they could observe, by lifting and lowering the mirror at arm's length, the perfect match between the image of the baptistery directly before them and its perspectival depiction. Here, Brunelleschi invented not only the foundational experience of perspective, but the first viewing *dispositif* in the modern sense: apart from the painting itself, the *dispositif* can only achieve the desired effect – the demonstration of the procedure – if the viewer agrees to be an integral part of it, looking with a single eye at one panel through the other by means of a mirror and positioned exactly in the sole spot in the world where this *functions*.

Brunelleschi's invention was thus crucially not a box, in particular because its goal was not to present an optical view: in order to demonstrate the accuracy of the construction, it had to compare natural and artificial perspective, and thus lower and raise its mirror. This is everything. This extraordinary *dispositif* inscribed movement in its very form; it cannot be a mere box, it is already a machine. In fact, movement is inscribed in it in a second manner: the part of the painted panel corresponding to the sky was not drawn by Brunelleschi, but rather covered with burnished silver, so that the scene's real sky, the movement of the clouds and the flight of birds, would be reflected there.[35]

By situating Brunelleschi's perspectival *dispositif* in the ensemble of his machines rather than in relation with his 'discovery of perspective', Francastel is able to carry out a profound historiographical deconstruction/reconstruction. Firstly, this confirms, of course, the connection, he argues, exists between technique and art, between mechanical invention and aesthetic renewal in this pivotal Quattrocento period,[36] echoing the connection he proposes exists in the contemporary era in his book *Art and Technology in the Nineteenth and Twentieth Centuries*.[37] But this also produces a connection, placing in this precise moment in the history of painting that of 'countless spectacles of public life', a concept applicable both to the theatre and to optical boxes, and all those machines whose point in common is moving, living, changing visualization. This was certainly the intellectual framework that led Francastel to assert in an article in the *Revue de filmologie* in 1949 entitled 'Espace et illusion' that 'it appears that the connection between cinema's origins and the "arts of illusion" – which flourished to such an extent in the eighteenth century – has not until now been explored sufficiently.'[38]

This shift towards the machine thus leads to a transformation of the connection to the image, to performed entertainment, to movement, and to the role of these in a cultural history that resituates cinema as a machine, a *dispositif*, and mode of representation in a longer historical arc.

35 Curiously, Francastel's description is erroneous, because he places the mirror part of the panel 'below to reflect the sky', as if the mirror's right-left inversion also involved an up-down inversion. It is as if, in fact, the image was not observed through a hole and with a mirror but rather through a photographic (or cinematographic) lens carrying out this dual inversion. The first description of this *dispositif* was written by Manetti (*Vita di Filippo di ser Brunellesco*, around 1480). It was later widely commented upon, in particular of course by Hubert Damisch in *L'Origine de la perspective* (Paris: Flammarion, 1987).

36 On the connection between the invention of perspective and Brunelleschi's professional practice, see Giulio Carlo Argan's fine essay 'The Architecture of Brunelleschi and the Origins of Perspective Theory in the Fifteenth Century': 'it is thus impossible to distinguish Brunelleschi's researches on perspective from his artistic activity, that is to say, from his architecture' (p. 103). This essay is also quoted by Francastel in 'Espace et illusion', 74.

37 Pierre Francastel, *Art and Technology in the Nineteenth and Twentieth Centuries*.

38 Pierre Francastel, 'Espace et illusion', 74. François Albera notes that Francastel worked with Louis Dimier on a study of these 'arts of illusion', for which he 'took notes under the title "La perspective des peintres et les amusements d'optique"'. See Albera, 'Pierre Francastel, le cinéma et la filmologie', 312. On the arts of illusion and their connection to cinema and contemporary art, see Laurent Mannoni, Werner Nekes and Marina Warner, *Eyes, Lies and Illusions: The Art of Deception*.

Machines and Movement, Machines and Images

It appears, however, that there is a fairly strong connection between machines, images, and movement. The Viennese philosopher Ludwig Wittgenstein's *Philosophical Investigations*, published posthumously in 1953, is not exactly a book of technology. And yet, Wittgenstein, from his exile in England, took up the question of what is, philosophically, a machine:

> The machine as symbolizing its action: the action of a machine – I might say at first – seems to be there in it from the start. What does that mean? – If we know the machine, everything else, that is its movement, seems to be already completely determined [...].
> We use a machine, or the drawing of a machine, to symbolise a particular action of the machine. For instance, we give someone such a drawing and assume that he will derive the movement of the parts from it. (Just as we can give someone a number by telling him that it is the twenty-fifth in the series 1, 4, 9, 16 . . .).[39]

Within a wide-ranging research framework focused on language and its uses, this section of Wittgenstein's book sets up a fundamental contrast between the machine 'as symbol' – the idea of the machine, or its image – and the 'real machine', which can function poorly, wear out, etc. Here, the machine appears to call up the image and movement; even to be defined as each. The machine both symbolizes and involves its 'particular action', and in principal is reduced to the entire determination of a series of movements constituting its action. To know a machine is precisely to know all of its movements. But knowing a machine means to become aware that all of its movements are already completely in the unique moment presented to us by the machine under observation itself or, especially, by its image – which appears here not to be an image in the traditional pictorial or photographic sense, but in the sense of a plan, a diagram, an explanatory drawing. An image of the mechanism of the machine. This image makes possible knowledge of the machine, knowledge that is concretely embodied in the ability to foresee all future movements – with the exception of the possible unexpected movements of the real machine. The actual machine contains all its future forms, just as the machine and its image appear to contain one another, to read Wittgenstein's prolonged hesitation between these two terms. The definition of the machine thus shifts entirely to the cinematic paradigm:

39 Ludwig Wittgenstein, *Philosophical Investigations*, § 193, p. 78.

'We might say that a machine, or the picture of it, is the first of a series of pictures which we have learnt to derive from this one'.[40] For Wittgenstein the machine is a 'cinematographical mechanism of knowledge' in a completely different sense than it was seen as such by Henri Bergson: for the mind, it is an image that produces, through the activity of its viewer's intellect, a series of images that develop potentially by means of deduction, beginning with the first. Here, the series of movements becomes a series of images.

The connections between machine, image, and movement are profound and intriguing, and crucial to Western culture. In 1968, Pontus Hultén organized an exhibition at the Museum of Modern Art in New York entitled 'The Machine: As Seen at the End of the Mechanical Age'.[41] The exhibition mixed machines and images of machines, from Leonardo da Vinci's drawings of flying machines to electronic works by Nam June Paik. The Lumière Cinématographe had a place in a series that also included, for example, Vaucanson and Jaquet-Droz's automata, paintings by Max Ernst and Francis Picabia, Marcel Duchamp's devices, Neuville's illustrations for Jules Verne's novels, and, of course, Calder's mobiles and Tinguely's 'meta-machines', which were one of the centrepieces of the exhibition. Here, cinema was no longer a part of the 'arts of illusion' as a whole, but rather of another history of considerable importance, that of machines and their depiction – as images or as spectacle.

The recent historiography of technique has shown the complexity and fertility of this history of the connections between machines and representation. In fact, the Renaissance was not only the moment when linear perspective was invented; it was also the moment of an upheaval in the techniques of architectural plans and engineering drawings, an upheaval that corresponded with a series of transformations of their functions.

Machines call for drawings for a variety of reasons: it must be possible to depict the construction project for the client, to establish an efficient means of communication between engineers and craftspeople or workers, to record ideas for later reworking, etc.[42] Verbal description is inadequate and ineffective; only the image – accompanied by verbal and quantified data (dimensions, etc.) – can produce knowledge of the machine making possible its construction and comprehension of it. Thus, the patent system joins, for each invention, an analytical description and explanatory diagrams.

40 Ibid.

41 K.G. Pontus Hultén, *The Machine: As Seen at the End of the Mechanical Age*.

42 Marcus Popplow, 'Why Draw Pictures of Machines? The Social Contexts of Early Modern Machine Drawings'.

But the machine calls for a particular kind of depiction. In 'The Emergence of Combined Orthographic Projections', Wolfgang Lefèvre has shown how the representation system commonly used in architectural and industrial drawings developed: by presenting an object in the form of two or three combined orthogonal projections – in perpendicular plans, one plan at ground level and two elevations. This made it possible to provide a range of information necessary to understanding the building or the machine. But this system did not suddenly appear, and Lefèvre shows the crucial role played in its emergence by Dürer in particular (Illus. 2). Dürer transferred this technique to architecture and then to painting, based, according to Lefèvre, on the practices of stone carvers.[43] In addition, Lefèvre argues, the seemingly much greater technical simplicity of orthogonal projection compared to linear perspective suggests that the former predates the latter, which, in fact, appears not to be the case.[44] Although perspective is more complex to construct geometrically, it appears to be older, undoubtedly because it is easier to grasp epistemologically. The principle of what today is known as orthogonal 'projection' was not known at the time, and the mathematization of space produced by perspective may have been a crucial epistemological prerequisite for a theoretical and practical comprehensive understanding of the issues around this 'projection' – this term, moreover, is anachronistic.[45]

Architects and engineers before the early sixteenth century, therefore, did not have absolutely precise means for representing their projects. But Lefèvre shows how these systems were only necessary for certain contemporary practices, in particular for a certain way of organizing professions and a certain connection to issues of tradition and innovation:

> As a rule, the architectural features of the planned building were not fixed in all their aspects and details in advance. Commissioner and architect confined themselves to appoint only main features when contracting. Above all two reasons seem to be responsible for this practice. First was the custom of postponing decisions on certain questions to a time when they could be made in light of the growing building. Second, and probably more important, was the fact that many features needed no explicit agreement because they were obvious within the given tradition of construction.[46]

43 Wolfgang Lefèvre, 'The Emergence of Combined Orthographic Projections', 238.

44 Ibid., in particular p. 235.

45 For a sketch of the history of uses of the term 'projection', see Michel Frizot, 'Un dessein projectif: la photographie'.

46 Wolfgang Lefèvre, 'The Emergence of Combined Orthographic Projections', 221.

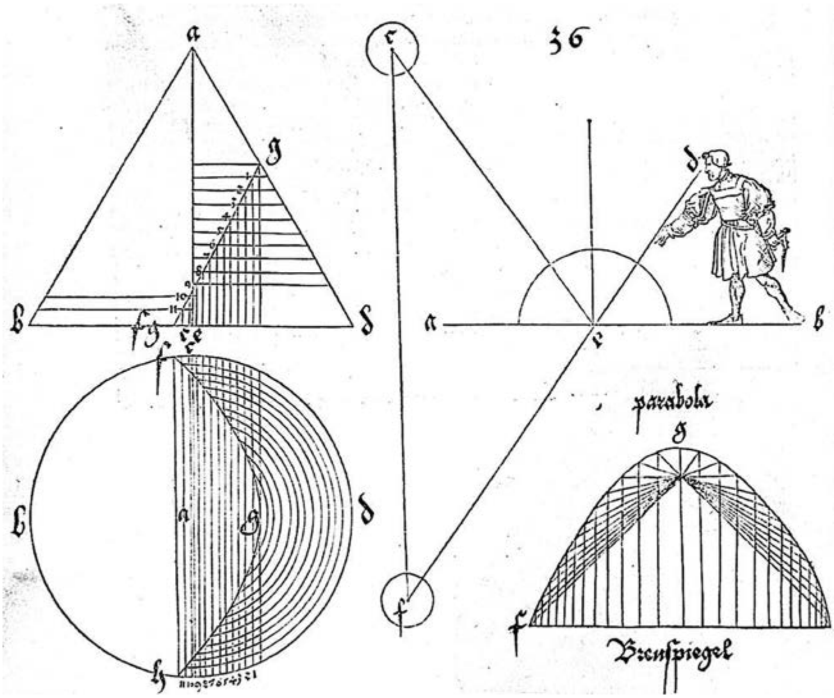

Illustration 2 – Albrecht Dürer, combined orthogonal projections, from Underweysung der Messung mit dem Zirckel und Richtscheyt, 1525.

It was thus within an 'improvisatorial building practice'[47] that architectural drawing techniques took on meaning until the fifteenth century. Today, the division of labour and the role of innovation in the organization of professional practices require – and produce – other techniques.

The complexity and fertility of the connection between machines and images is tied up with the other element discussed by Wittgenstein: the connection between machines and movement. To depict machines is basically to have to depict an action, a movement, and to depict it in such a way that beyond the form of the machine strictly speaking *the form of its movement* is also made clear. Knowledge of machines is not distinct from knowledge of movement. What came to be the science of machines, the *kinematic*, was one of the branches of knowledge born with the nineteenth century. The concept of the 'kinematic', formulated in particular out of Gaspard Monge's lectures at the École Polytechnique in the very earliest

47 Ibid., 222.

years of the institution at the turn of the century, and then formalized by Ampère in his *Essai sur la philosophie des sciences*[48] in 1834, was a means for the systematic study of machines, and in particular for classifying their fundamental elements: mechanisms. The kinematic would develop throughout the century at engineering schools, giving rise to several important volumes authored by Charles Laboulaye[49] and Franz Reuleaux. At the beginning of his 1885 course at the Faculté des Sciences in Paris, Henri Poincaré provided the following fine definition: 'the kinematic is the study of movements independently of the things which caused them, or more exactly the study the study of all possible movements.'[50] These remarks display a thrilling ambiguity: the science of machines is, precisely, the science of movement.

It was not by chance, moreover, that one of Monge's most important scientific contributions was the theorization of descriptive geometry, defined here by Charles Dupin: 'The first goal of this science is to depict, on two-dimensional drawing sheets, every three-dimensional body in nature. The second goal is to deduce from such a depiction all the mathematical relations resulting from the form and position of these bodies'.[51]

This science, whose usefulness for military and civil engineering Dupin was already emphasizing, has been the basis for methods of depicting machines since that time.[52] Descriptive geometry, based on orthogonal projection, produces a conventional visual depiction focused on the object rather than on space and respecting the ratio of magnitudes. It makes it possible to recognize immediately the object depicted on the basis of the drawing's visual resemblance, but does not involve a perceptual 'realism' of the same kind as traditional linear perspective.

Thus, machines and buildings call for the image – they call for an always multiple and plural image, for series of images or combined projections. In return, these images demonstrate not only the internal organization or the

48 André-Marie Ampère, *Essai sur la philosophie des sciences, ou Exposition analytique d'une classification naturelle de toutes les connaissances humaines*, 50. In this later edition 'technology' is defined on p. 97.

49 Charles Laboulaye, *Traité de cinématique, ou Théorie des mécanismes*. Reprinted as *Traité de cinématique théorique et pratique, ou Théorie des mécanismes*.

50 Henri Poincaré, *Cours de M. H. Poincaré professé pendant l'année 1885-1886: Premiere partie: Cinématique pure – Mécanismes*, 1.

51 Charles Dupin, *Essai historique sur les services et les travaux scientifiques de Gaspard Monge*, 96.

52 Ibid. See in particular the chapter 'Géométrie appliquée à la mécanique', 142-144.

configuration of machines, they also demonstrate, directly or indirectly, in their very form, in the representational techniques employed, the range of contemporary practices that produced them and through which they take on meaning. With them, they become a system. A 'network of adherences' holds together all these elements, technical and visual, gestural and mechanical. Machines call for images, but these are singular images with a singular connection to their subject: a subject whose fundamental quality is, precisely, *a certain kind of movement*.

The Machine and the Non-Verbal

There is, therefore, an obligatory passage through the image which, even if we were not to push the equivalency of the image and the machine to the same indeterminacy as Wittgenstein, constitutes one of technology's strong methodological specificities. Already between the late sixteenth and late eighteenth centuries 'machine theatres' were folio printed books made up of

> a series of full-page figures, often very handsomely printed, accompanied by a caption and a brief commentary. Each plate, engraved on wood or copper, depicted a machine or an instrument in perspective in a landscape, a workshop or an abstract space. There the author depicted 'various greatly necessary secrets to every Republic, as useful as they are delightful' of which he declared himself to be the inventor.[53]

The first and perhaps most famous of these theatres, the *Théâtre des instrumens mathematiques et mechaniques de Jaques Besson, Dauphinois, docte Mathematicien: Avec l'interprétation des Figures d'icelui, par François Beroald*, which went through several editions between 1578 and 1602,[54] showed 60 figures on odd-numbered pages. For each, on the verso, was a 'proposition by the author' setting out the function of the machine and its novelty, along with a 'declaration of the figure' that sketched an analytical description (Illus. 3). The figures were not plans or diagrams but perspectival engravings showing the machine alone or with its users. The perspective was sometimes altered by somewhat odd foreshortenings, because the clarity of the machine's operation had to take precedence, although this was an entirely relative clarity.

53 Luisa Dolza and Hélène Vérin, 'Figurer la mécanique: l'énigme des théâtres de machines de la Renaissance', 9.
54 For details on the editions, see ibid., 35-36.


PROPOSITION DE L'AVTHEVR
SVR LA XIIII FIGVRE
AVTRE MACHINE NOVVELLE: LAQVELLE POSEE EN SEMBLABLE LIEV, QVE LA PRECEDENTE, FAIT PAR L'OEVVRE D'VN SEVL HOMME (EN TEMPS DE NECESSITE) LE MESME QVE LA DEVANT DICTE AVEC DEVX, AINSI QVE SA DELINEATION, ET RAISON MATHEMATIQVE LE MONSTRENT.
Declaration de la mesme Figure XIIII.
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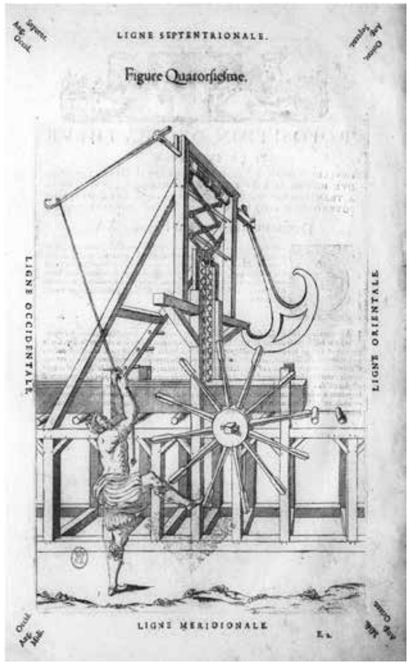


Illustration 3 – Théâtre des instrumens mathematiques et mechaniques de Jaques Besson, Dauphinois, docte Mathematicien: Avec l'interprétation des Figures d'icelui, par François Beroald, 1578.

Subsequently, technological volumes continued systematically to be illustrated. The French edition of Franz Reuleaux's *Kinematics of Machinery*, one of the most important books of this kind in the nineteenth century, was published 'with 459 engravings in the text' and was, in addition, accompanied by a detachable and foldable 'atlas' made up of eight large plates.[55] This time, however, the engravings and plates were geometrical diagrams or depictions of mechanisms drawn strictly to scale in orthogonal projection. Henry T. Brown's volume *Five Hundred and Seven Mechanical Movements*,[56] published in the United States in 1868, had a layout close to that of the volume by Besson: plates of diagrams on the left-hand page and commentary about them on the right.

55 This 'atlas' appears not to have formed part of the English edition published a year earlier. See Franz Reuleaux, *The Kinematics of Machinery: Outlines of a Theory of Machines*, and *Cinématique: Principes fondamentaux d'une théorie générale des machines*.
56 Henry T. Brown, *Five Hundred and Seven Mechanical Movements*. Various modern-day reprints of this volume exist.

Similarly, André Leroi-Gourhan's foundational article on 'comparative technology' illustrated the method in three plates containing 75 drawings by the author (Illus. 4).[57] And Louis Lumière's letters on strictly mechanical problems, in particular those letters to the engineer-inventor Jules Carpentier, in charge of the industrial production of the Cinématographe – and (thus) in charge of its fine-tuning – are the only published Lumière letters to be accompanied by sketches and diagrams, explaining the problems to be solved.[58]

The machine's affinity with the image – along with that of technique – thus takes concrete, material shape in the seeming impossibility of *explaining* a machine without at a certain moment *depicting* it. This aspect is one of the important specificities of technology as a discipline and of the history of technique: they are massively confronted with the 'non-verbal'. In fact, in 1963, Francastel described the need for 'awareness of the existence of visual thinking irreducible to any other kind,' something he described as 'one of humankind's major systems of thought in history': 'This thinking has the singular quality, among many others, of using a non-verbal medium or base. In this sense it is, with verbal thinking and mathematical thinking, one of the three forces of the human mind'.[59]

This distinction is crucial for Francastel, for this is what justifies the sociology of art project: 'Today, works of art provide us with the largest ensemble of still-unused documents on life today and in past societies. One of the goals of the present generation should be the incorporation of non-written sources into the history of civilizations'.[60]

The problems this incorporation poses are, primarily, methodological, and then, inseparably, theoretical and epistemological: 'There is no doubt [...] that we cannot align the methods and values arising out of this thinking with the methods and values which a society's other major modes of expression display, in particular verbal thinking and mathematical thinking'.[61]

The analysis and history of machines and of technique in general pose similar problems, precisely because they are largely a part, if not of 'visual thinking' then in any event of 'non-verbal' thinking.

As we will see later on in the concrete cases I will examine, the way techniques are constituted and evolve eludes complete and conscious

57 André Leroi-Gourhan, 'L'Homme et la nature' 7, no. 10, 8, 7 and 15, and 7, no. 12, 2.

58 See Auguste and Louis Lumière, *Letters*, 55ff.

59 Pierre Francastel, 'Valeurs socio-psychologiques de l'espace-temps figuratif', 93 and 92.

60 Ibid., 93.

61 Ibid.

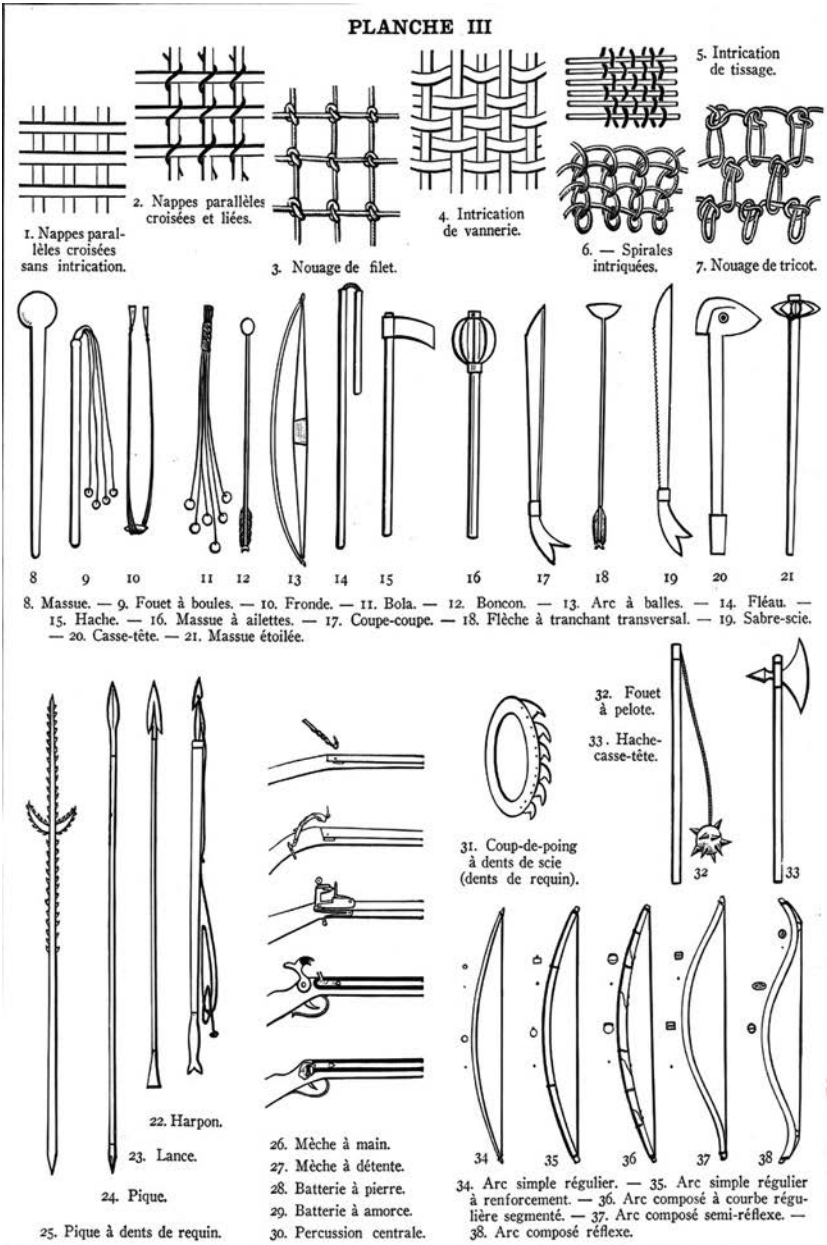


Illustration 4 – Technical instruments compared. Drawings by André Leroi-Gourhan, 'L'Homme et la nature'.

verbal formalization. Ways of doing are learned and transmitted through explanation, but also by example and imitation. The potter or woodworker's 'artistry', which gives the material its 'correct form', can be depicted but can be described only with difficulty. It is even more difficult to justify it by means of rational and completely coherent arguments. When Marcel Mauss defined a technique as an '*effective traditional act*',[62] he was referring to the fundamentally historical and collective nature of technique. But *tradition* evokes a way of being a part of an oral or gestural and non-written history, one that can be pictured but not theorized. Similarly, machines can be described or explained – in their patent for example – but these descriptions are never complete and could not ever be so, because some elements of a machine will elude such description. These elements are not necessarily the most complex: those are the heart of the matter, the central point of the patent. Rather, it is the most obvious things, the things which at a certain moment in history go without saying for the inventor, the reader, the user. For example, the architectural features that 'did not need to be explicitly discussed because they were obvious within a given construction tradition,' in Lefèvre's description. These features were not verbalized in contracts or elsewhere because the parties saw no interest in doing so. Doing so would prolong texts and discussions indefinitely and needlessly. Above all, the parties were no longer even aware of these features' existence. They were the local 'paradigm', in the words of Thomas Kuhn; they could only be reconstructed through an intermediary step of reconsidering the objects themselves, and the images of these objects. It is a matter, in Francastel's words, of 'striving to recreate, through ensembles of works, the characteristic figurative systems of a given milieu and era, thanks to which it becomes possible for us to complete or rectify our general interpretation of a given period of history.'[63]

These non-verbal aspects are valuable precisely because they engage and operate under the aegis of epistemological systems on a level situated *prior* to the verbal and the formulated. They are the means to accede to the parts of these systems that their users themselves are unaware of – in the way, in Walter Benjamin's description, the photographic machine could give access to something like an 'optical unconscious'. The Lumière Cinématographe's intermittent cam was abundantly discussed and described explicitly in numerous texts by the Lumières and their contemporaries, and until recently as well, as a fundamental contribution to their machine. But never did

62 Marcel Mauss, 'Les Techniques du corps'. Reprinted in *Sociologie et Anthropologie*, 371.

63 Pierre Francastel, 'Valeurs socio-psychologiques', 94.

Lumière or anyone else in cinema's written history, theory, or technology before the mid-1990s describe the lenses used, for example. This *given* of the machine was thus not the subject of any discourse, even though its concrete application was extremely important, a point to which I will return. An analysis of the Cinématographe focused on discourses around it could only perpetuate this overlooking – or suppression – of the camera lens. It is thus up to a technological analysis of the Cinématographe machine to take on the task of studying these two of its organs – the cam, but also the lens – while at the same time taking into account their respective presence and absence in discourse on the machine.

The hypothesis of the specificity of 'visual thinking', beginning with its non-verbal structure in particular, is connected to discussions of the possibility of isolating a characteristic form of 'technical thinking'[64] distinct from scientific thinking, as well as of the possible function attributed to it. This question was essential, for example, for Georges Canguilhem, whose first two scholarly papers, in 1937 and 1938, took up technique, precisely. His *Essai sur quelques problèmes concernant le normal et la pathologique* of 1943 announced a turn to the study of medicine, in that it is 'a technique or art at the intersection of several sciences'; more particularly, it is 'a technique for establishing or restoring normalcy.'[65] Canguilhem would be a central figure in raising the question of technique in the scientific field in the post-war period, as Lucien Febvre was before the war.

The first of these two papers, 'Descartes et la technique', is an affecting picture of a Descartes of small things, ultimately creating a kind of suggestive self-portrait of the doctor and epistemologist:

> One feels an admiring surprise at seeing Descartes take up indiscriminately and with the same conscientious methodical intelligence the most special and the most disparate technical problems: smoking chimneys, elevating waters and draining swamps, medical diagnoses, the use and dosage of medicines, fountains believed to be miraculous, automata, the trajectories of cannon balls, the speed of bullets, the strength of swords, the sonority of church bells.[66]

64 This is the title of a volume by Julien Pacotte published in 1931. See *La Pensée technique*.
65 Georges Canguilhem, *Le Normal et le pathologique*, 7-8.
66 Georges Canguilhem, 'Descartes et la technique'. Reprinted in Jean-François Braunstein and Yves Schwartz, eds., *Oeuvres complètes*, vol. 1, *Écrits philosophiques et politiques (1926-1939)*, 493.

Here, the consideration of techniques seems to be less a philosophical decision than a kind of quality of attention and a rejection of the traditional hierarchies of the noble and the insignificant. It represents the idea that not only 'the size of lenses for optical instruments, the construction of machines and medical art' – which constitute 'the most common topics of his thoughts' – but also 'the routines of the simple country dweller and the soldier'[67] engage his thinking. There is a decided interest in technique, and Descartes' greatness is also to have 'not disdained "lowering his thinking to the least inventions by mechanics".'[68]

In his text, Canguilhem describes technique as 'an action which is always to some degree synthetic and thus impossible to analyse' – which is 'not, from a Cartesian point of view itself, to deprive it of all value, because to do so is to see in it a means of creation, however inferior it may be.'[69] A 'technical synthesis' can be creative in various ways, but it is as a synthetic action that it can outpace or 'shame theory', which is essentially analytical. This synthesis is that of *passing to the act* of creation, he would say in 1938 ('theoretical lucidity can never be an adequate reason for passing to action'[70]), which means that technique can be conceived in the framework of a 'theory of creation, meaning at bottom an aesthetic.'[71]

This synthesis that is the technical action or object is what makes it elude complete reducibility to the verbal and what constructs its affinity with the image. It is the task of an epistemology of machines to develop methods to make it possible to express this non-verbal part as well as the verbal part and to grant both their role, in Francastel's words, in a 'general interpretation of a given period of history'– within a certain *episteme*,[72] in the end, confronting this fundamental dimension of technique with the conceptual and paradigmatic meshing of contemporaneous thinking.

The Performance and the Device: Machines-Archives

Techniques and practices thus constitute a specific level where things that elude theory, or even verbal formulation by practitioners themselves, are

67 Ibid., 492.

68 Ibid., 493.

69 Ibid., 497.

70 Georges Canguilhem, 'Activité technique et création', 26 February 1938 session of the Société toulousaine de philosophie. Reprinted in *Oeuvres complètes*, 504.

71 Georges Canguilhem, 'Descartes et la technique', 497.

72 See the sense given to this Foucauldian concept by François Albera and Maria Tortajada in 'L'Épistémè "1900"'.

discovered. Their essentially gestural and traditional nature makes them a fleeting subject that is difficult to apprehend. How to write their history? How to recover the means of reliably describing ways of doing about which we do not, precisely, have written records? In the field of media, how, exactly, can we succeed in reconstructing in a coherent manner the performative practices of a past era – with the dimension *performance* proving, to be essential in the perceptions of users, viewers, and operators?

In the introduction to his book *Canadian Film Technology, 1896-1986*, the former head of technical operations and research of the National Film Board of Canada, Gerald G. Graham, provides some autobiographical context:

> My father started the family career in show business as a ticket taker in the Dominion Theatre in Ottawa (1910). Shortly thereafter, he was operating the Edison Vitascope projector when film programs were introduced as fillers between stage shows. The projector was located in the open at the front centre of the balcony. The absence of a projection booth was not an oversight on the part of the management, since the projectionist was also required to enforce order among balcony patrons while the lights were out. The projected film was collected in a bushel basket, or simply fell on the floor, and had to be sorted out, cleaned and rewound between shows.[73]

This brief description provides a number of interesting pieces of information on the kind of performance that could make up a film screening around 1910, at least in this Canadian movie theatre. The procedure described appears quite different from the image we may have of such events: here, as Graham points out, the projectionist was not shut up in a booth but worked in plain view, despite the technical difficulties. The reason was not to exhibit the *dispositif* in a manner related to some supposed remnant of the 'novelty period' of film exhibition, but in order to economize on labour costs: in this way, the operator could also and at the same time keep order. It thus appears that in the early 1910s the projector was not always hidden from public view.

But what importance should we attach to this report? Graham offers a precise description, but he remains an indirect witness (he was born in 1917), writing several decades after the events. In addition, it is difficult to know how widespread the practices of the Dominion Theatre in Ottawa were.

73 Gerald G. Graham, *Canadian Film Technology, 1896-1986*, 15. It appears that the Dominion Theatre became Bennett's Theatre and was later torn down.

Performance is, precisely, the most evanescent and elusive dimension of the film medium, the one that, by definition, leaves the fewest traces. What we can know about it comes from the descriptions of participants; in most cases, these descriptions are those of viewers and thus oriented towards what they came to see, i.e. the screening, the films, and the attractions, not the venue or the overall setting. There are no archives of performances as such, of the concrete operating practices and protocols of film projection or of shooting a film.

But performing a media consists of putting into operation a certain technical *dispositif*, a machine, and how this machine was conceived is not a neutral matter. On the one hand, this conception itself is formed according to the pictured use of the machine, in keeping with contemporary practices. As Gilbert Simondon wrote, 'What resides in machines is human reality, human gestures fixed and crystallized into working structures'.[74]

Machines, as solid and durable by nature as performance is ephemeral, thus constitute in themselves archives of gestures. They record the memory of uses in objects. This is the perspective of André Leroi-Gourhan's 'comparative technology' project. As he remarked in 1943 in *Évolution et techniques*, 'ethnology can, up to a certain point, make predictions about a tool's handle and its use as a whole from the shape of its blade.'[75]

Tools, therefore, trace that which cannot be reconstructed by any other document: the history of techniques is a form of archaeology. But this requires knowledge, which makes possible deductions – from the blade to the handle and then the tool as a whole and finally to its use.

In his 1961 article quoted above,[76] Georges Friedmann emphasized the need for technology for the sociology of labour he had in mind:

> The study of instruments and devices which make up the work station is technology [...]. The study of labour cannot do without a profound familiarity with its technical conditions [...]. Labour is inscribed in the structure of the tool and the machine to the point that, in pre-historical or historical periods for which we have no document to explain the practical forms of labour, these forms take shape through the discovery of an instrument or tool.[77]

74 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, 18. (Translation modified – Trans.)

75 André Leroi-Gourhan, *Évolution et techniques*, vol. 1, *L'homme et la matière*, 15. Quoted in Jean-Pierre Séris, *La Technique*, 58.

76 Friedmann published in *Annales* a review of the first volume of Georges Sadoul's *Histoire générale du cinéma*. See Georges Friedmann, 'Sur une histoire du cinéma'.

77 Georges Friedmann, 'Sciences sociales et sociologie du travail', 478.

Here, machines no longer seem to be a collection of mechanisms, but rather to belong to an ensemble called the 'work station'. They contribute to structuring the worker's tasks and to organizing the relations between professions. A Technicolor camera from the early 1940s, built for what was known as Technicolor process 4 (a three-colour process that was practically the sole method for producing colour films in Hollywood until the 1950s), ran three black-and-white film strips simultaneously behind a single lens equipped with a beam splitter and three coloured filters. It thus weighed much more than other cameras, was much bigger, and made more noise. It had to be enclosed in a soundproof blimp, which made it even heavier and more cumbersome: it could no longer be handled by a single person. It required a greater mechanical set-up and, as a result, was usually attached to a dolly in order to move it about. It brought with it a whole range of heavy and complex operating procedures and a mode of production that required a particular kind of economical operation, while organizing the working methods of the camera assistants, camera operators, and technicians.

In a different technical sphere, time marking on the image film stock and on the sound tape, invented by Jean-Pierre Beauviala for his company Aäton, is a procedure that is strictly internal to devices, as it is carried out inside the camera or sound recorder.[78] And yet, its implications for the way film shoots are organized were immediate, as this system was invented in order to dispense with the clapper, which synchronizes the sound and image of every shot. But the effects of the invention were different according to the use to which it was put. In 'traditional' fiction, time marking enables the technician in charge to avoid disrupting the actor's concentration with an ill-timed *clack* right in front of their face. In documentary film, this system – used for example by Robert Kramer in *Route One/USA* (1989) – makes it possible to avoid disrupting the activities of the people being filmed, but also to start up the camera and the tape recorder independently of each other. The sound recorder can record without interruption (sound tape is much cheaper than motion picture film) while the camera operator or the film director can decide to stop and restart the camera without losing synchronization.

In these concrete examples, the intertwining of machines and practices and of devices, working methods, professional hierarchies, the economic conditions of production, and even aesthetic projects, is apparent. Machines thus function as archives of practices and gestures, and the history of

78 See Jean-Pierre Beauviala, 'A Revolutionary New Approach to Time Marking on Film, Sound and Video Tape'.

techniques becomes an archaeology of machines. A movie camera from 1945 or 1915 tells us about the way they were used by cinematographers of the day; a projector from 1903 or 2013 informs us what viewers saw in screening venues in those times.

For, in the case of media *dispositifs*, machines seem to be archives on a different level: that of modes of perception and systems of representation. In his article 'The Stereopticon and Cinema', Charles Musser emphasizes the importance of a number of changes to cinema's *dispositif* that appeared simultaneously in the latter half of 1903. The first of these changes was the introduction in the United States of 'the three-blade shutter on motion picture machines, which sharply reduced the flicker effect and made spectatorship much more pleasurable. Before this moment, the cutting back and forth from slides to film was not only common but desirable.'[79]

From that time on, the screening could thus be made up of only films, without alternating with the projection of magic lantern slides, and films began to get longer and more structured. But we must qualify this claim. First, as early as 1896 a projector such as the Biograph, which used wide-gauge film (69mm) at high speed (about 30 frames per second), had much less flicker than its competitors.[80] Later, the 1910 *Kinemacolor Handbook* reveals that, at the time, it was still quite common for the operator of a 'cinema' (or rather, in the local parlance of the day, a Bioscope), to *also* acquire a magic lantern when purchasing a movie projector. This attests – once again *through machines* – to the fact that long after 1903, fixed images continued to alternate with moving pictures. The case of Kinemacolor, however, is unique in several ways, to which I will return below.

In any event, Musser's hypothesis does not revert to technological determinism, or see as mere technical 'progress' the very astute and theoretically exciting idea of reducing flicker when showing moving pictures by *adding* a blade to the projector's shutter: to reduce flicker, one needs more rapid flicker. Firstly, we must note that the precise observation of machines from a given period provides us with valuable information on the exact form of the presentation they produced. From there we must construct not a linear history of techniques guided by the notion of progress, but an archaeology of techniques that reconstructs the coherence of each of them, and its cohesion with a certain kind of entertainment, the 'network of adherences' that ties it to a certain cultural ensemble. This should also remind us that the

79 Charles Musser, 'The Stereopticon and Cinema', 157.
80 On this point see Paul C. Spehr, *The Man Who Made Movies: W.K.L. Dickson*, 419.

reconstructions of the early moving pictures we have today are effectively only facsimiles, even when they are seen on 35mm in the original aspect ratio and at the original speed. To what extent can we understand these moving pictures, as they were shown and commented on at the time, without seeing them projected as they were projected then – with a particular lens and a particular shutter, lamp, take-up mechanism, screen, power source, etc.? The 'preservation of projection practices' Fossati spoke of has not taken place in this case, apart from a few very rare attempts to reconstruct original screening circumstances.[81] It has become impossible to relive the real *visual experience* of a Méliès Kinetograph screening or a Robert William Paul Theatrograph screening – to *see* the coherence between the form of the moving pictures and the technical conditions of their perception. It remains that, in this case and a few others, the preservation of machines makes it *possible in principle* to repeat such an experience, which the machines have archived as a *potentiality*.

Machines/Systems

Machines are archives because they are not autonomous entities; instead, they are integral parts of broader formations, which can be defined differently depending on one's approach. These formations are what André Leroi-Gourhan called a 'technical milieu'[82] and Bertrand Gille a 'technical system':

> As a rule, all techniques are, to varying degrees, dependent on one another, and there must be a certain coherence among them. This ensemble of coherences at different levels of every structure of every ensemble and of every sector makes up what we could call a technical system.[83]

A technical object thus finds itself caught up in a vast network of interdependencies, which, on the one hand, makes possible its existence and, on the other hand, assigns it a precise function. For a movie camera to exist, there must be manufacturers capable of making it with the precision needed for it to function, at a cost that allows for its commercialization. There must also

81 In particular at the Conservatoire des techniques of the Cinémathèque française, headed by Laurent Mannoni.

82 André Leroi-Gourhan, *Évolution et techniques*, vol. 2, *Milieu et techniques*, 47.

83 Bertrand Gille, 'Prolégomènes à une histoire des techniques', 19.

be, in traditional photo-chemical cinema, manufacturers of film stock with a form (width, thickness, size and positioning of the sprocket holes, solidity, etc.) that is compatible with the camera machine. There must be laboratories for treating this film stock and efficient circulation systems to move the film stock between factory, laboratory, and shooting location. One then needs places to show the result. In digital cinema, one needs manipulation software and media on which to store the productions in digital laboratories; here, too, one must organize the circulation of the material. 'Film' cameras still exist today and, if well preserved, these machines will be able to be used for quite a long time; but if no one is manufacturing film stock, or if all the photo-chemical laboratories close or simply no longer maintain their developing baths, these cameras will become largely unusable. Their material existence as objects is not in question as such, but industrial transformations bring about a change in the technical system, and in the new system their function as machines is no longer assured.

The technical object is thus tied to systems in two ways, whereby it constitutes an objectification, and thus an archiving, of its historical state. In Simondon's formulation, on the one hand, 'the operator's gestures are also part of the technical reality,' while, on the other, 'technical objects are part of technical ensembles.' Thus, 'technical objects cannot be considered as absolute realities and as existing by themselves, even after having been constructed. Their technicity can be understood only through the integration of the activity of a human user or the functioning of a technical ensemble.'[84]

To analyse machines, Simondon established a distinction between three technical levels. In *On the Mode of Existence of Technical Objects*, he calls these levels the *element*, the *individual*, and the *ensemble*;[85] in his 1968-1969 course on invention, these categories became 'sub-ensembles or elements', '*technical networks*', and 'individualized technical objects, those Lafitte named, precisely, *machines*' – with the particularity that 'the individualized technical object, whose elements are multi-functional, join the network's organizational mode with that of the sub-ensemble or element.'[86] Simondon's *technical ensembles* or *networks* are not Gille's 'technical systems': for Simondon, a mine, for example, is a technical network, bringing together transportation systems (on one's back or by wheelbarrow, sled, or wagon on rails, etc.), ventilation systems, water pumping systems and systems for

84 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, 245.

85 Ibid., 53ff.

86 Gilbert Simondon, *L'Invention dans les techniques*, 163-164.

lowering workers into the ground and for extracting minerals (the mine shaft). The ensemble can only function by coordinating each of its elements.

In our quest to describe our object of study technologically, we must remember that, in this context, the term 'cinema' can describe several distinct and complementary entities:

– a *principle*: the illusion of movement by means of the rapid succession of a series of images. This definition, however, is debatable, and subject to caution and possible objections, as it appears that no fixed definition can be given. It is interesting to note nonetheless that the cultural and epistemological unity of 'cinema' has not seemed particularly threatened, at least until the appearance of the digital, even though it functions on the same bases. This principle could be carried out technically in several different ways (the intermittent advancement of a light sensitive tape, periodic scanning of a photo-luminescent screen by an electron, etc.), each of which has seen various distinct working forms. This level is the *element* or the *component*, to use Simondon's terms: it refers to what happens *inside machines*. In the terminology used by François Albera and Maria Tortajada, it is on this level that the 'internal *dispositif*' is located.[87] This is also the level in question, for example, in Henri Bergson's analysis in the chapter on the 'cinematographical mechanism of knowledge' in his book *Creative Evolution*.
– a *dispositif*, in the sense Albera and Tortajada use the term: a determined relation between a viewer and a show involving images put into motion with added sound through the use of machinery; here, the term describes a mechanical and architectural ensemble. Here, too, this *dispositif* has seen and still takes a great number of profoundly different working forms: those geared to large audiences (the movie theatre), small audiences (domestic *dispositifs* or *dispositifs* accessible to a limited number of people: televisions, computer screens) or to a single viewer (Kinetoscope, Mutoscope, portable television, Moviola, mobile telephone); commercial and non-commercial (classroom, scientific laboratory, factory); permanent or temporary; professional (35mm, D-Cinema) or amateur (16mm, Super-8, DV and HD video, amateur projector), etc.[88]

87 François Albera and Maria Tortajada, 'The Dispositive Does Not Exist!', 22.

88 Roland Barthes, 'Première Conférence internationale sur l'Information visuelle (Milan, 9-12 juillet 1961)', 224. On this text, see François Albera and Martin Lefebvre, 'Présentation: Filmologie, le retour?', 30.

Individualized cinema machines directly tied to production or reception are located on this level – cameras, projectors and, if one must include 'passive machines', venues.

It should be noted here that the proliferation of devices that struck commentators in the nineteenth century (optical toys and visual shows of all kinds, from the Thaumatrope to the Diorama) and has struck those in the twenty-first (the profusion of contemporary media objects) is a constant throughout the history of the medium. The history of cinema as a *dispositif* limited to the experience of moving images in a paid-admission dark theatre is a history of film theory, but it is not a history of cinema.

The Spirograph, for example, invented by Theodore Brown in 1907, was a cinema projector made for domestic use and employing a flexible acetate disc measuring 26cm in diameter and holding some 1200 images (Illus. 5). It was commercialized by Charles Urban in the early 1920s. The Spirograph catalogue contains several hundred titles. The filmmaker Werner Nekes' collection contains a great number and a great variety of optical *dispositifs* dating from before the twentieth century, but it also contains a 1957 Radiocinéphone, a combination of telephone receiver and turntable for playing record albums and small-screen 16mm sound-film viewing *dispositif*. This collection also contains a Scopitone, an audiovisual jukebox produced by the Cameca company in 1958[89] and intended for use as a coin-operated machine for group viewing – albeit the size of the audience could hardly be 'a large crowd'. These devices have been overlooked by film theory and forgotten by film history. Like many others, they testify to the extreme and constant diversity throughout the twentieth century of the ways in which moving pictures were received. Here, we should recall Roland Barthes' remarks in the first issue of the journal *Communications* in 1961: 'cinema's imperialism over other forms of visual information today can be understood historically, but cannot be justified epistemologically.'[90]

– a *technical network*, in the sense in which Gilbert Simondon uses the term: here, 'cinema' describes the organization of all the machines (cameras, printers, editing tables, projectors, etc.), places (production studios, laboratories, screening rooms, factories where machines are made, etc. – illus. 6), technical procedures and forms of circulation amongst these elements, which enable the production of a concrete cinema object and ensure its presence in the culture. This network can

89 See Bodo von Dewitz and Werner Nekes, eds., *Ich sehe was, was du nicht siehst! Sehmaschinen und Bilderwelten: Die Sammlung Werner Nekes*, 403-404.

90 Roland Barthes, 'Première Conférence internationale', 223-224.

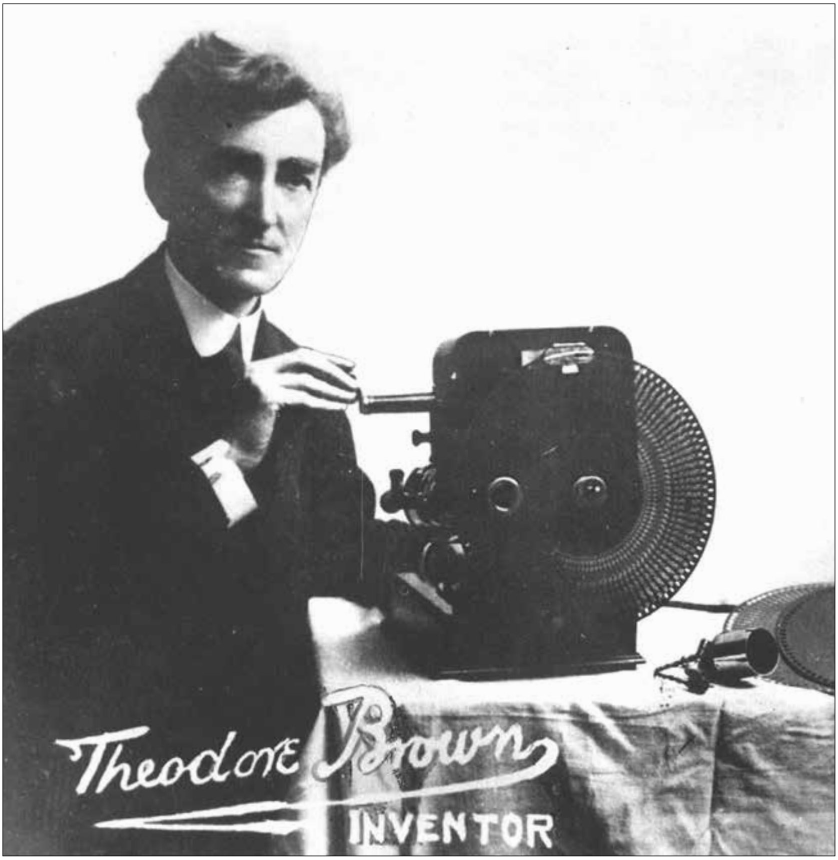


Illustration 5 – Theodore Brown exhibiting his Spirograph (from Stephen Herbert).

be vast, even global (a 'Hollywood'-style cinema, industrially produced and distributed worldwide) or limited to more specialized distribution systems (experimental cinema, educational cinema, professional training cinema, political cinema) or even to the most minimal form possible (films made and shown by a single person, sometimes with a single machine: the home movie). Of course, even in this latter case a technical ensemble is implied, making the functioning of this mini-network possible. The level of the network is structured by the circulation of a base (film stock, a digital file on disc, a server or other ad hoc material element): the 'film', evolving from its component parts to its final form. This network is also structured by a variety of factors, in particular the way the professions involved in each of its levels are organized (performers, technicians and creative collaborators, engineers, manual workers, etc.).

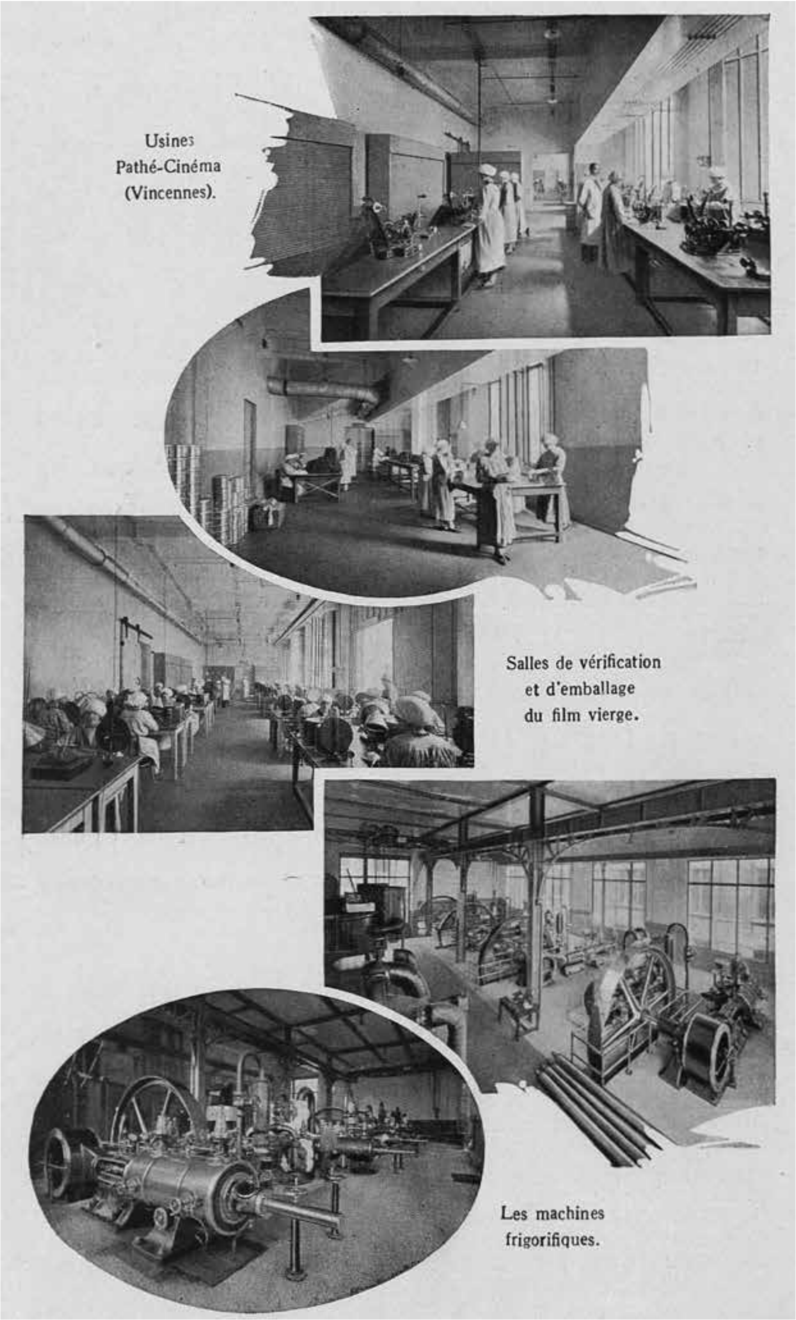


Illustration 6 – The Pathé plant (le Film vierge Pathé. Manuel de développement et de tirage, 1926).

A technology of cinema should examine each of these levels, as well as the way they interact. But it should not do so in the abstract – according to a general and ideal 'cinematic principle' – but rather by a precise analysis of singular historical cases in which the principle is seen to materialize. For it is these singular cases, in the opacity of their coherence, which can inform us about what has taken place.

An Example: The Principle and Machines – The Camera Obscura

The camera obscura, mentioned above, is an exemplary case of an extremely diverse ensemble of machines unified by a fundamental principle, described here by Leonardo da Vinci:

> If the front of a building or some piazza or field which is illuminated by the sun has a dwelling opposite to it, and if in the front which does not face the sun you make a small round hole all the illuminated objects will transmit their images through this hole and will be visible inside the dwelling on the opposite wall which should be made white.[91]

Already, this description shows that apart from the principle, the result is tied to certain precise technical points: the size and shape of the hole, the direction it faces vis-À-vis the sun, the white wall-screen. It is no longer an abstract configuration per se, but a real machine subject to operating constraints. In another fragment, Leonardo 'receive[s] this images on a white paper placed within this dark room rather near to the hole.' In this case, the objects will appear 'in their proper form and colours,' not only inverted, but also 'much smaller.' The paper-screen 'must be extremely thin and looked at from behind.'[92] This is a completely different set-up: the screen becomes mobile, the images are transformed, and the machine is accompanied by precise instructions for its use.

This machine would undergo its first major transformations in the sixteenth century, notably the addition of a lens for sharpness (Illus. 7), or even two lenses combined in order to put the image upright. Then, in the eighteenth and nineteenth centuries, the machine saw a great many variations. In particular, as we know, it became portable: the first known version was that of Canaletto in the mid-eighteenth century, famous for his

91 Leonardo da Vinci, *Notebooks*, 108.

92 Ibid., 110.

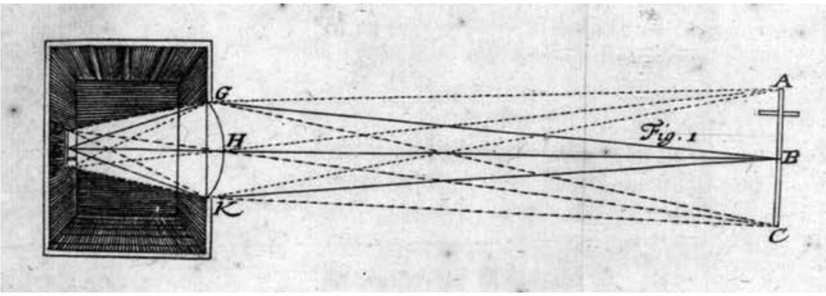


Illustration 7 – A camera obscura and its lens. William Molyneux, Dioptrica Nova, 2nd ed., 1709.

pictures of Venice and prints of engravings. This machine went from being a 'chamber' (*camera*) to a 'box', or to one of their possible intermediaries (folding tent, etc.). Each time, certain constraints had to be observed: one needed a lens and a screen, which should be white, a good distance from the lens, and itself shaded from direct light.

Today, we tend to subsume these machines into the category defined by the general principle, but also to see them as having the same use, by thinking of the camera obscura only as an aid to drawing or – in the work of Jonathan Crary, for example – as an epistemological model for vision. This reduces the machine to an abstract property of geometrical optics. The 'explanation of the way in which vision is made,' in the volume *La Dioptrique oculaire* by Chérubin d'Orléans[93] (Illus. 8) is exemplary of a moment when the scientific and the allegorical could merge. Here, the image is produced in a camera obscura, but this camera obscura is not an organ and not an eye, nor is it an abstract or empty place: it is an office with thick walls containing pencils and a work table, orbs, and a door closed with a solid metal lock. If this figure represents 'the way in which direct vision is made,' we must conclude that thought and knowledge, but also the intimacy of these constructions, are not immaterial to this – that they are the very site where 'direct vision' is produced. This epistemological role is, therefore, indisputable. But the historical phenomena which envelop it are singularly complex.

We should note, firstly, that the camera obscura is not an obvious choice of method for assisting in perspectival drawing. In *On Painting* (1435), the foundational treatise on the theory of linear perspective, Alberti describes his 'intersectional veil,' which he presents as his own invention: 'a veil

93 Chérubin d'Orléans, *La Dioptrique oculaire, ou la théorique, la positive et la mécanique de l'oculaire dioptrique en toutes ses espèces*, 64.

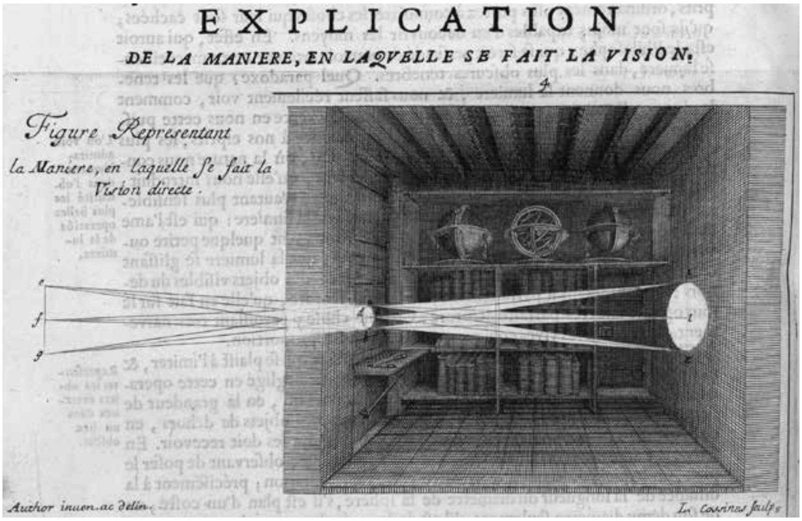


Illustration 8 – 'Explanation of how the image appears'. Chérubin d'Orléans, Dioptrique oculaire, 1671.

woven of very thin threads and loosely intertwined, dyed with any colour, subdivided with thicker threads according to parallel partitions, in as many squares as you like, and held stretched by a frame.'[94]

A century later, Dürer, in his classic and fundamental *Underweysung der Messung mit dem Zirckel und Richtscheyt*, presented four perspectival methods – two in the first edition of 1525 (the glass panel and the window[95]), to which he added two others in the second edition of 1538[96] (the method attributed by him to Jacob Keser, and the grid, which was a variation on the intersectional veil – Illus. 9). Each of these methods was adapted to a precise use: the portrait (the glass panel or the grid); foreshortening objects (the window); or, finally, when one wanted to adapt the glass panel to a painting in which the distance from the point of view to the surface of the painting was greater than arm's length (the Keser method). This latter technique was an astute solution to a concrete technical problem.

These volumes were crucial manuals for painters and were foundational in the history of perspective. Yet, none of them included among the methods

94 Leon Battista Alberti, *Leon Battista Alberti: On Painting*, 176.

95 In which the 'point of view' is disassociated from the painter's eye and the visual ray 'conveys' in the form of a suspended thread, making it fascinating theoretically.

96 See Albrecht Dürer, *The Painter's Manual*, 431-437.

Illustration 9 – The perspectival grid procedure. Albrecht Dürer, Underweysung der Messung mit dem Zirckel und Richtscheyt, 1525.

for obtaining perspective the camera obscura, even though it was already well known. At the same time, the history of the camera obscura, apart from the history of perspective, is itself extremely complex.

After these mentions in the work of Leonardo and a few others, the camera obscura would be widely popularized as an instrument of 'natural magic'. This trend was begun by Giambattista Della Porta in *Magiae Naturalis*, a fundamental volume for the culture of the day. The first edition of this book was published in four volumes in 1558 and it was republished in a new version made up of twenty books appearing for the first time in 1589. There were numerous translations and reprintings. Laurent Mannoni has pointed out the description found in this latter version of true spectacles put on through the intermediary, the mediating, of a camera obscura: an entire stag hunt, with the hunters, the animals, real or fabricated trees, children playing in the vicinity, every gesture and movement, even noises and the sound of trumpets, appeared on a white sheet before friends seated in the camera obscura.[97] Della Porta mounted other examples of these *prestiggi* – paintings that, cleverly lit, seemed to make their images float, in the middle of the night, above the heads of the assembly.[98] This connection between the camera obscura and *spectacle* is fundamental to its history, as can be seen in this comment by Jonathan Crary:

> Many contemporary accounts of the camera obscura single out as its most impressive feature its representation of movement. Observers frequently

97 Laurent Mannoni, *The Great Art of Light and Shadow: Archaeology of the Cinema*, 9.

98 See the Italian translation of this passage by Della Porta (in the Naples edition published by Antonio Bulifon in 1677) in Laurent Mannoni and Donata Pesenti Compagnoni, *Lumière et mouvement: Incunables de l'image animée*, 48-52.

> spoke with astonishment of the flickering images within the camera of pedestrians in motion or branches moving in the wind as being more lifelike than the original objects.[99]

Crary insists on this point: it is this ability to render movement in particular that distinguishes the camera obscura from 'experience of a perspectival construction.'[100] In fact, this cultural – and technical – use of the camera obscura continues today, when other uses have been lost. In a few places in the world one still finds examples of the camera obscura, which one pays to observe from inside it the spectacle of the world around it – a *point of view* – in the form of images transmitted to a dark room through the use of lenses and mirrors. One of the most remarkable, according to John Hammond, is the Great Union Camera in Douglas on the Isle of Man, probably built in 1887 and still in operation today. Its roof is equipped with eleven skylights, each with a lens and a mirror, which project the view onto eleven tables arranged in a circle in the centre of the room.[101] It is thus a camera obscura, but in the form of a paid show that, since the 1880s, has presented, horizontally, moving images to large numbers of people – and whose form is closer to a panorama than to what one pictures when one thinks of a camera obscura. Others of the same sort were set up at the Clifton Observatory in Bristol; in Portmeirion, Wales; in Edinburgh, Scotland; in Marburg, Germany; and in San Francisco (built in 1939). In 1935, the optical engineer and amateur astronomer Horace E. Dall had one built on the roof of his home in Luton, England.[102]

This tradition developed in a partially autonomous manner, or, in any event, independently of the idea of using the camera obscura as an aid to drawing, or even of perspective. That said, how radical this independence was is debatable: the camera obscura was one of the very rare image production *dispositifs* some of which projected images onto *horizontal* screens, even though the initial form employed vertical screens: the walls of the room. And horizontal image *dispositifs*, precisely, were those variants made to assist drawing, with the screen becoming a table. In 1900, Theodore Brown produced a *dispositif* that reversed this principle: the Designoscope, vertically projecting drawings made on the spot by the operator.[103] The horizontal

99 Jonathan Crary, *Techniques of the Observer*, 34.

100 Ibid.

101 John H. Hammond, *The Camera Obscura: A Chronicle*, 145.

102 Ibid., 147-152.

103 Described in the supplement to the *British Journal of Photography*, January 1900. See Stephen Herbert, *Theodore Brown's Magic Pictures: The Art and Inventions of a Multi-Media Pioneer*, 16-17,

presentation of images in these panoramic camera obscura, such as that of Douglas, was not the obvious choice: the panorama-like form of the building suggested rather that the images be cast onto the walls. By presenting these images on a horizontal table, this *dispositif* became more a part of the history of the camera obscura, in a sense, than that of the panorama. The machine thus carries in its form a history that surpasses it.

Of course, the camera obscura was *in addition* an important *dispositif* for assisting in the making of perspectival drawings. It was described in *Pratica della Perspettiva* by Daniele Barbaro, for example, ten years after the first edition of his *Magiae Naturalis*, as a 'natural way to put in perspective,'[104] although it was not employed as such in any significant way for another century.

But these histories intersect with another. While Della Porta's *Magiae Naturalis* seems to us today to be a book of 'white magic', the ambiguity of its status in the culture of its day can be seen in the fact that it was closely read by the savant Johannes Kepler. If a critical shift in the epistemology of optics took place with Kepler and the publication of *Ad Vitellionem paralipomena* in 1604, the camera obscura played a very important role in this. Gérard Simon[105] has demonstrated the extent to which Kepler's adoption of an experimental approach brought about profound changes in optics. We can easily describe this experimental approach as consisting of truly thinking through technically the camera obscura 'machine'. This thinking through took place in a particular scientific context, in which astronomy played an especially important role, with the *Paralipomena* addressing the 'optical part' of the question. In it, the study of eclipses is central, and it is noteworthy from this perspective that the first known illustration of a camera obscura describes, precisely, its use in watching an eclipse, making it possible to observe an eclipse without damaging one's eyes, and possibly to retain a trace of the positions of the heavenly bodies on the screen. Reinerus Gemma-Frisius used this method to observe an eclipse of the sun in Louvain on 24 June 1544 and published an

which describes how this principle was present in the nineteenth-century tradition of scientific magic lanterns, vertical-projection devices from which are descended the transparency projectors familiar in today's classrooms. Others variant of this mode are, of course, the *dispositifs* used in animated cinema.

104 Daniele Barbaro, *La Pratica della Perspettiva*, 192. This *camera obscura* is mentioned after Dürer's 'window method'. Barbaro is famous for having been among the first to mention the addition of a lens – 'un'occhiale da vecchio', an old person's eyeglass.

105 The following discussion is largely based on Gérard Simon's volume *Archéologie de la vision: L'optique, le corps, la peinture*, 207-213.

illustration of it the following year in his *De Radio Astronomica et Geometrica*. Kepler was familiar with this use of the device. But the instrument was not without problems: in some cases, it appeared to introduce measures that contradicted direct observation (when not in eclipse, it showed the diameter of the moon appearing one fifth smaller). Kepler sought to resolve this problem through technical study of the camera obscura and the precise conditions under which its image was formed. I will not outline every aspect of this endeavour in detail, but it involved several stages.

The first thing Kepler examined was the size of the opening of the chamber. This opening should be very small, much smaller than the (angular) size of the light source and negligible in comparison. If it were not, and the hole were too large, the image of the opening itself would be superimposed on that of the object being observed, blurring perception of it and misrepresenting its size. That said, if the opening were really too small, the image would not be adequately lit. *Real* cases, i.e. not the abstract cases described by geometrical optics, thus made compromise necessary.

The second thing Kepler studied was the screen. He carried out an experiment, by moving the screen inside the camera obscura, placing it at different distances for the opening through which the rays of light entered. He thus saw both the source image – the inverted image – and the image of the hole itself – a right-side-up image – take shape and dissolve. Each point of the source then had to be seen as producing on the image not an equivalent point but rather a spot that, under optimal technical conditions, could be reduced approximately to a point.

He then proposed two technical improvements. The first consisted of placing a glass flask filled with water behind the hole. He observed that by moving the screen to a particular spot, the image became sharper than before, and sharper than anywhere else in the space. He demonstrated the reason for this by geometric means: the spherical dioptre made the rays of light coming from the same point of the source converge again in a single point.

But his demonstration also proved that through the spherical dioptre the rays of light distant from the axis passing through the centre of the hole and the flask were more refracted than the others and were dispersed, no longer converging in a single point. He thus placed a diaphragm between the hole and the dioptre, preventing the marginal rays of light from disturbing the formation of the image.

All these experiments resulted in a number of crucial new inventions for the history of optics as a science. They were the result of Kepler's interest not only in the fact that an image is formed, but in the quality of that image and the technical conditions that influence it. Here, taking into account technique – the material, the way the machine and its procedures are inscribed in the image itself – was foundational on a theoretical level and produced an epistemological rupture. For, after the connection between the eye and the camera obscura had been identified, by Leonardo da Vinci in particular, these experiments led Kepler to understand the true architecture of the eye and the respective functions of the cornea, the pupil, the iris, and the retina, *by analogy* with what he had observed about the camera obscura. He definitively identified the camera obscura's role as an epistemological model for describing and thinking about vision, a role that would become fundamental in later years. Thus, there was born in his thinking a sense of the instrument's true effective power – and, more precisely, a manner of *technical thinking about the instrument*.

Kepler's position in this instance corresponds to what Georges Canguilhem describes in his article 'Descartes et la technique':

> Knowledge of nature, according to the *Dioptrics* essay, thus doubly depends on human technique. First, in the sense that the instrument, in this case the magnifying glass, serves for the discovery of new phenomena [...]. Next and above all in the sense that technical imperfection provides the 'opportunity' for theoretical research through 'difficulties' which must be resolved. Science proceeds from technique not in the sense that the true is a codification of the useful, a recording of success, but on the contrary in the sense that technical obstacles, lack of success and setbacks, invite the mind to inquire into the nature of the resistances encountered by human art, to perceive the object independently of human desires and to seek true knowledge.[106]

The imperfection of the camera obscura as an instrument led Kepler to research that is theoretical because it is, in the first place, experimental, i.e. technical. His research emerged in reaction to the observation that a number of 'difficulties', which Kepler elaborated and *posed as problems*, in the strongest sense of the term, through the very form of this research.

Various elements of these developments around the camera obscura are relevant to our discussion here. Firstly, the instrument partially corresponds to the distinctions established with respect to 'cinema'. In fact, the term 'camera obscura' can describe both a fundamental *principle*, which gives unity to the whole, and *machines*, which involve casting the principle

106 Georges Canguilhem, 'Descartes et la technique', 496-497.

into different forms, conceived each time with regard to a specific task, a specific use, and a specific conceptual context and imaginary. At least three fundamental technical lines develop out of the principle; each is distinct, but the three are joined by a number of shared properties, although with great variation between individual devices – even if the unity preserved in the term camera obscura shows that their variety is still perceived culturally as a coherent whole. Schematically, we can describe the first strand as scientific: here, the camera obscura is an instrument, with its constraints with respect to precision and reliability, which makes measurement possible. In the second, the camera obscura is a *dispositif* for assisting in perspective drawing – from this viewpoint it is as much a tool as an instrument. This strand appears considerably later, and would give rise to portable *dispositifs* showing images on horizontal screens making it possible to create an outline superimposed on the image. In the third strand, finally, the camera obscura is a machine for producing moving image shows for audiences of varying sizes. This is a *dispositif* in the limited sense in which Albera and Tortajada employ the term. Depiction of movement is crucial for this third group; this is clearly not so in the first case, and is mostly an inconvenience in the second.

Laurent Mannoni emphasizes that Della Porta's presentation of the camera obscura as a *dispositif* for creating spectacle reveals a connection between the camera obscura and the cinema. And yet this connection *does not at all involve photography*. In a different sense, the connection between the camera obscura and photography seems undeniable in certain respects, technical above all, as can be seen in the texts written by Daguerre himself in which he described the daguerreotype as consisting in 'the spontaneous reproduction of images of nature received in the camera obscura, not with their colours but with great subtlety in their tonal gradations.'[107] This connection can also be found on the cultural level, but solely in the case of the camera obscura as *an instrument to assist in drawing*, as seen in Arago's report to the Chamber of Deputies at its session of 3 July 1839, which establishes this clearly.[108]

We should view this in relation to the fact that in the early years of photography no ontological distinction was made between photographic images and drawings, as seen in texts of the period. In 1849, for example, Joseph Plateau could propose to apply photography to the Phenakisticope:

107 Louis Daguerre, *Historique et description des procédés du Daguerréotype et du Diorama rédigés par Daguerre*, 57.
108 Reprinted in ibid., 10-11.

> One could make plaster casts, for example, of the models of the sixteen modifications to the sequential figure whose image one wishes to produce in the combined device we are concerned with, and then *take with a daguerreotype a couple of drawings* of each of these sixteen models, and finally transpose these drawings onto the two discs.[109]

This clearly dates from *before* the 'photographic snapshot', but it also dates from before the separation of drawing and photography as two ontologically opposed means of producing images: here, the daguerreotype is seen as a particular way of 'taking' a drawing. Because today the drawing/photography distinction is radical and completely assimilated, the connection between the camera obscura and photography is no longer comprehensible.[110]

These strands are not, of course, hermetically sealed, and taking them into account should not reduce the singularity of each device in belonging to one or another group. One of the most famous classical illustrations of the camera obscura is also certainly one of the strangest and most enigmatic. It appears on plate 27 of the first edition of Athanasius Kirchner's *Ars magna lucis et umbrae* in 1646 (Illus. 10). Although often reproduced, it is rarely commented on.[111] The two other figures in the plate show images produced by nature itself: images (or letters of the alphabet) that appear on stones or on cut trees, created without human intervention; and anthropomorphic landscapes. The lower third of the page shows a scene with a human figure that will be explained a few pages further on.[112] Kircher describes his camera obscura as a *machine*. It consists of a double cubic chamber that appears, on this scale, nearly four metres across. Except for two apertures on the exterior walls, opposite each other, there is no opening onto the outside. The interior walls are screens onto which images are projected. A square trapdoor at the figure's feet clearly serves as an entrance and exit; the chamber sits on two long wooden beams, suggesting what the text confirms: the chamber is 'portable': 'it can be carried easily by two men,' reads the description. The man inside is wearing elegant clothing (only one person is shown, but one

109 Joseph Plateau, 'Troisième note sur des applications curieuses de la persistance des impressions de la rétine'. Quoted in Jacques Deslandes, *Histoire comparée du cinéma*, vol. 1, *De la cinématique au cinématographe, 1826-1896*, 73. My emphasis.

110 As can be seen in Jonathan Crary, *Techniques of the Observer*, and in Martine Bubb, *Camera obscura: Philosophie d'un appareil*, 313-315.

111 See par example Jonathan Crary, *Techniques of the Observer*, 63.

112 Athanasius Kircher, *Ars magna lucis et umbrae in decem Libros digesta*, 812. The first known published illustration of a magic lantern appeared in the second, expanded edition of this volume in 1671.

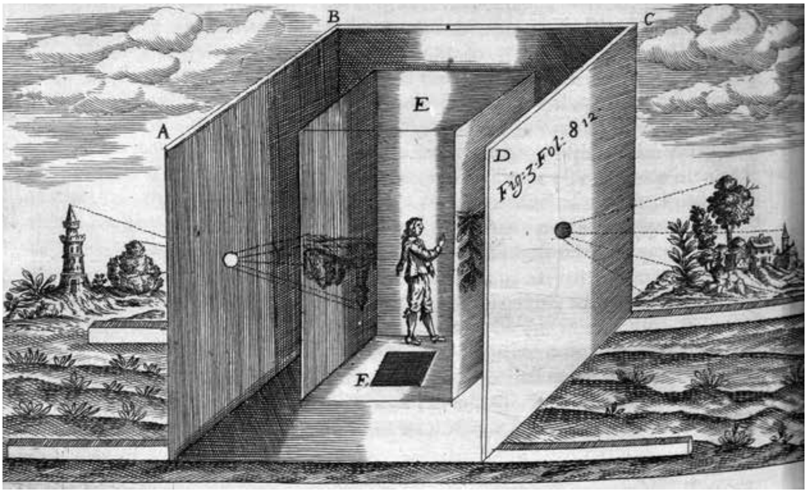


Illustration 10 – A strange camera obscura. Athanase Kircher, Ars Magna Lucis et Umbrae, 1646.

can imagine that there was room for several others); he has one hand raised in front of him in a way suggestive of a painter's gesture, but he has no tool with him. This could also merely be a gesture of attentively pointing out a detail in the image before him.

The images produced by this machine are two landscapes, inverted left-right and top-bottom, with the engraving barely smaller than the original (a one third reduction in the case of the landscape on the left and no reduction of the bush in the landscape on the right). But this is not the only distortion of perspective in the engraving: the original landscapes seem dislocated with respect to the perpendicular to the walls represented by the beams on the ground. The landscapes are clearly in the background, and presented to us frontally when they 'should' be at a right angle. These distortions of perspective could appear contradictory if the goal was to vaunt the camera obscura as an instrument that, precisely, fabricates images in perspective.[113]

This machine is enigmatic for several reasons. Firstly, it appears technically improbable: two men could not 'easily' transport a set-up like this. In addition, it is hard to see how it stands up and of what material the interior wall could be made for it to be rigid and yet transparent. John

113 But these distortions were not rare in treatises on perspective. See Eduardo Ralickas, 'Reflections on the Pragmatics of the Illustrated Perspective Treatise: Performative Failures and (Pre-) Romantic Innovations'.

H. Hammond has suggested that it is not depicted to scale and that, in fact, it may have been 'large enough to admit the head and shoulders' rather than an entire person.[114] For Hammond, it resembles the model described 50 years later, in 1694, by Robert Hooke, an oblong set-up enclosing the painter's head (Illus. 11);[115] it also resembles the Swiss artist Alfons Schilling's *Dunkelkammerhut* (1984, illus. 12).[116] Yet, the difference in dates and technical equipment (Hooke's machine clearly has a lens, while Kircher's appears not to) makes this doubtful, as well as logically incoherent: the painter would have an image literally behind his head, unable to see it and without any need to, because with a sole opening/lens, he only had to turn in the other direction to view the other part of the landscape.

Kircher's machine is also exceptional because it is dual: a double wall and especially a double landscape shown simultaneously in front of the observer and behind his back. The viewer can or must turn around in the machine in order to join the two images – or to paint them in turn, perhaps according to the orientation of the sun, lighting particular parts better at certain times of the day?[117] Kircher summarily describes some of the possible uses of his machine. Artificial spectacles of every description could be depicted in it. From it, one can observe hills, camps, forests, humans, animals, and diverse scenes in such a way that 'no painter's art would suffice to draw such variety.'[118] The machine could also, of course, be of use to the painter who wanted to depict all these things.

It is not my goal here to reduce the strangeness of Kircher's machine, which is *actually* absolutely singular and improbable. Nor is my goal to reject the *dispositif* in the name of this improbability. Kircher's illustration traces a project that has *a degree of consistency* with practices of the day – uses of the camera obscura, illustration practices – and thus belongs entirely to the post-Renaissance episteme.

114 John H. Hammond, *The Camera Obscura*, 26.

115 Ibid., 23.

116 In Nike Bätzner, Werner Nekes and Eva Schmidt, eds., *Blickmaschinen oder wie Bilder entstehen: Die zeitgenössische Kunst schaut auf die Sammlung Werner Nekes*, 44.

117 Peter Greenaway has undoubtedly best shown the use of perspective machines, in *The Draughtsman's Contract* (1982). The device in the film is a 'grid' and not a camera obscura. One changed position while painting according to the orientation of the sun. Complete immobility on the part of the figures being painted was required – thus residents and workers disappeared, for example.

118 Athanasius Kircher, *Ars magna lucis*, 812.

Illustration 11 – Robert Hooke's portable Camera obscura (1694). From John H. Hammond, The Camera Obscura: A Chronicle.

But in this plural vein of machines described by the expression camera obscura, should we think that there was a sole early invention followed by occasional innovations, or should we identify various major inventions? What would the criteria be for such a distinction, if it were to make sense and have value? These questions are inseparably technological and historiographical.

Illustration 12 – Alfons Schilling, Dunkelkammerhut, 1984 (MAK – Museum of Applied Arts, Vienna).

2. Invention, Innovation, History

Abstract
The terms 'technological invention' and 'technological innovation' pose a dual problem from the outset: that of defining an invention and an innovation, and that of defining the technological. This twofold problem, at once historiographical and theoretical, raises another in passing: does this question have any specific aspect in the case of technological innovation in the cinema? Or, what is yet another problem: does this question have any specific epistemological aspect in the case of film history and theory? Elements from the history of the viewfinder or of editing show the importance of an epistemology of machines. The approach is developed through a detailed analysis of Wheatstone's stereoscope.

Keywords: Innovation, invention, historiography, viewfinders, editing, stereoscope.

The terms 'technological invention' and 'technological innovation' pose a dual problem from the outset: that of defining an invention and an innovation, and that of defining the technological. This two-fold problem, at once historiographical and theoretical, raises another in passing: does this question have any specific aspect in the case of technological innovation in the cinema? Or yet another problem: does this question have any specific epistemological aspect in the case of film history and theory?

Innovation in Cinema and the Film Spectator

Technological discourses on the film medium have largely been built on a now-classical schema connecting a very limited number of invariable fundamental moments: the emergence of the base *dispositif*, the arrival of sound and colour, and then that of a few other less crucial or partially futuristic elements: widescreen cinema, special *dispositifs* (Imax, Showscan, etc.),

Turquety, B., *Inventing Cinema: Machines, Gestures, and Media History*. Amsterdam: Amsterdam University Press, 2019.
DOI 10.5117/9789463724623_CH02

3D cinema. This segmentation structures both Jean Vivié's *Historique et développement de la technique cinématographique* (1946)[1] and Steve Neale's essay *Cinema and Technology: Image, Sound, Colour* (1985),[2] to take two classic examples. The division volumes such as these establish is undoubtedly intended to be historical, involving a more or less precise periodization, but it also has a strong theoretical aspect, or rather it is manifestly organized according to a strong theoretical conception of the medium: cinema is moving photographic images, with the addition of the supplements sound and colour. We might ascribe to these supplements a theoretical value of increased realism (the drive towards 'total cinema') or power of attraction; nevertheless, they remain supplements, and adding or subtracting them does not dent the medium's fundamental integrity. From this perspective, there are clearly two distinct levels: one related to the creation of a new *dispositif* (the cinema), and the other consisting in 'improvements' – to employ the term found most often in cinema-related patents since the very earliest days – or variations of this fundamental *dispositif*. It is precisely in these 'improvements' that cinematic 'innovations' lie.

It should be noted that these variants correspond to a particular kind of transformations of the cinematic machinery: those perceptible by the viewer in the screening venue, engaging a major transformation of the viewing experience. Black-and-white or colour, 'silent' or 'talking', the shape and size of the screen: these are visible manifestations of the *dispositif* in a particular circumstance, which are emphasized and made use of by a film's publicity and that involve both the film and the venue. They plainly modify the way the show is perceived by the viewer, and thus the way in which the nature of the show and its possibilities are conceived by the viewer-theorist.

It appears, of course, as fundamentally legitimate to define the key moments in the medium's technical evolution according to the linkages perceptible by its receiver, the person for whom the overall experience is designed, the 'customer'. But this legitimacy can be questioned. It presupposes in particular that the most important technical innovations should all be identifiable by this particular category of users of a *dispositif*, those of the finished product. As a result, it is these users, the viewers, who define what is innovative in technical history – and not, for example, the production workers or engineers, the film directors, directors of photography, sound engineers, chemists, colour timers, editors, or engineers at Kodak, Panavision, Nagra, Steenbeck, etc.

1 Jean Vivié, *Historique et développement de la technique cinématographique*.
2 Steve Neale, *Cinema and Technology: Image, Sound, Colour*.

Film historiography and theory are constantly taking cognizance of this principle, seeing these immediate changes to the viewer's experience as technical innovations. Once again, it seems 'natural', i.e. legitimate and consistent, for film history and theory in general to focus on the receiver, and yet it remains true that these discourses, which ultimately define what a 'technical innovation' in cinema is, are produced outside the technological history of the medium properly speaking. They are constructed on an epistemological field – film history and theory in general – which has its own questions and issues specific to it and its own history, and these things are not necessarily what I have just called the 'technological history of the medium properly speaking.' Supposing, of course, that this 'technological history properly speaking' exists.

We should note from the outset that this positioning on the basis of the viewer is not without several concrete difficulties. These appear more clearly in the present circumstances, those of the introduction of so-called D-Cinema techniques, meaning digital movie-theatre projection. These circumstances tend to be seen as a new fundamental moment in the medium's technological evolution, an unprecedented upheaval, a 'revolution' or a 'transition', or in any event the end of cinema as we have known it until now. Yet, as John Belton has remarked,[3] the extreme cultural and theoretical importance granted to this 'digital moment' is rather paradoxical, in that it sees as a radical break an event that explicitly announces itself as *changing nothing about the viewer's movie-theatre experience*. Naturally, our means of access to moving images have multiplied – but they have been multiplying for a long time, in fact from the beginning, and ever since – but the discourse of equipment manufacturers and producers, along with that of institutions tasked with establishing projection standards (the Commission supérieure technique de l'image et du son [CST] in France and Digital Cinema Initiatives [DCI] in the United States), consists of reassuring viewers that they will not notice any difference. This, moreover, has strategic consequences in that, as Belton remarks, 'one obvious problem with digital cinema is that it has no novelty value, at least not for film audiences.'[4] While 3D may have potential publicity value, digital projection on its own does not. It is strange, moreover, that no one has seemed to want to cast into doubt the inevitable nature of the very costly shift to digital for all film production and exhibition, when only distributors, unlike any other sector of the

3 John Belton, 'Digital Cinema: A False Revolution'.

4 Ibid., 114.

industry (producers, exhibitors, viewers, archivists, etc.), have any real interest in such a shift.

While it is clear that digital procedures bring about a number of technical changes with substantial consequences, these consequences are situated on another level from the underlying viewing experience – unless we were to enter into the details of perceptual questions (such as the effect of the shutter), which are trickier questions to address, particularly because of their very perceptibility by the viewer (by the average viewer, i.e. the non-technician) is a much discussed topic. We are, by definition, in the presence of a technological transformation that raises issues different from those of previous cases; these were presented as profoundly reconfiguring the viewer's experience. And yet, contemporary theory unanimously acknowledges this transformation as a major technological innovation whose implications are set out in volumes that in no way present themselves as technological studies, but rather as works of theory or of cultural history, from the volume edited by Thomas Elsaesser and Kay Hoffmann in 1998, *Cinema Futures: Cain, Abel or Cable? The Screen Arts in the Digital Age*[5] to David Rodowick's 2007 volume *The Virtual Life of Film*,[6] to mention just two examples.

Innovative Techniques

The question arises, then, as to whether there are other systems for defining this strange thing, 'technical innovation' – in cinema, but perhaps also in general.

In his introduction to the special issue of *Annales* in 1935 on techniques, Lucien Febvre asked: 'what does it mean to "write the history of techniques"?'[7] Febvre provided a three-part response. Firstly, to write such a history is to 'become clear on the way workers acted in different eras in each trade or industry.' He called this a 'technical history of technique'. Next, one had to study the linkages between technical inventions and scientific evolution on the one hand and to situate these techniques within human activity as a whole: economics, politics, art, religion, etc. This triple parallel development, necessary to the discipline, highlights the extent of the

5 Thomas Elsaesser and Kay Hoffmann, eds., *Cinema Futures: Cain, Abel or Cable? The Screen Arts in the Digital Age*.

6 David N. Rodowick, *The Virtual Life of Film*.

7 Lucien Febvre, 'Réflexions sur l'histoire des techniques', 531.

methodological difficulties: new textual but also iconographic and material sources to discover and make use of and multidisciplinary collaborations to build between technicians and historians of various backgrounds.

Yet, the historiography of technique shows that, although Febvre saw 'the technical history of technique' as fundamental from every perspective, this has remained the most neglected field right up to the present day. In 1969, Maurice Daumas complained that 'our insufficient knowledge of the technical history of technique can justify in part the distortions [...] we too often see when a general history takes up the question of the history of technique.'[8]

In fact, he accuses economic history even more harshly: 'Economic history has dictatorially taken over the history of technique. It takes this history in the state in which it is found naturally and, with great strides, imposes on it its method of analysis and its major interpretive themes'.[9]

In cinema, as elsewhere, the history of technique tends to be seen and even constructed from outside by a general history or an economic history.

This latter approach was advocated by Douglas Gomery, for example, in his study of one of the key moments for the traditional historiography of cinema: the Hollywood film industry's transition to sound. In 1976, he proposed that sound films'

> advent can be appreciated by viewing it in terms of the economic theory of technological innovation, which posits that a product or process is introduced to increase profits in three systematic phases: invention, innovation, and diffusion.[10]

Here 'invention' describes that part of the process which takes place in the obscurity of the laboratory – those of the companies AT&T and RCA, in the present instance. Next comes the innovation phase, defined as the 'adapting of an invention for practical use'[11] and attributed to the companies Warner Brothers and Fox. Finally, 'the final phase, diffusion [...] occurs when the product or process is adopted for use,'[12] is the phase involving the 'industry' as a whole. Yet, as Edward Buscombe pointed out in the journal *Jump Cut* in 1978, 'economic theories can only partially explain technological innovations;

8 Maurice Daumas, 'L'histoire des techniques: son objet, ses limites, ses méthodes', 11.

9 Ibid., 13.

10 Douglas Gomery, 'The Coming of the Talkies: Invention, Innovation, and Diffusion', 193-194.

11 Ibid., 194.

12 Ibid.

economics cannot say why innovations take the form they do, only why they are an essential part of the system.'[13]

In fact, nothing here explains, for example, the reasons for choosing a sound on disk system, (the Warner Vitaphone system) on the one hand, or a sound on film system (the Fox Movietone and RCA Photophone systems) on the other, when the technical implications of each option, but also the aesthetic, theoretical, epistemological, and even economic implications, were crucial.

In addition, this division into phases supposes a clear break between a 'research' process that involves only scientists in their laboratories, and an 'adaptation' process that involves only practitioners, whose contribution cannot be located on the major level of invention, but rather in superficial conformance with professional practices, themselves presumed therefore to be unchanged. This clearly hierarchical division overlaps the presumed division between science and technique, such as that between an engineer and a 'skilled worker'.

In cinema, the history of technique poses the same problems as it does in overall history: properly technical questions, addressed from outside by general theory or by economic history, disappear or are deformed, shaped by the issues and method of these theories. This encourages in particular approaches that privilege Febvre's third chapter, that of technique's connection to the social, without the concrete reality of the techniques themselves having been understood in all their complexity.

Invention and the Shape of History

This notion of innovation remains one of the evident keys to the technological question, if only because of the role it plays in historiography and the few ways in which, in contrast, it has been interrogated. It, along with several other topics, was the subject of a course entitled *L'Invention et le Développement des techniques* given by Gilbert Simondon at the request of Georges Canguilhem at the Sorbonne and the Écoles normales supérieures in Paris in 1968-1969. There, Simondon took up the traditional paradigmatic pair *invention* and *innovation* in order to set new definitions of them based on the specificities of the genesis of technical objects in such a way as to account for the historical and historiographical issues they raise. Simondon distinguished two kinds of evolution of what he called 'technical objects',

13 Edward Buscombe, 'Sound and Colour'.

corresponding in part to two fundamental levels of their mode of existence: 'the technical object is, on the one hand, a mediator between organism and milieu, and on the other hand a coherent, an internally organized reality.'[14] Based on this conception, Simondon described the two levels of technical evolution:

> Speaking fairly generally, relational progress [around the technical object's adaptation to its surroundings] is gradual and made up of continuous improvements, achieved by trial and error through use. It results from experience and accumulates: it preserves the appearance of a connection between organism and surroundings. On the other hand, the progress of [internal] self-relation requires a resolution of the problem, an invention establishing a synergetic compatibility system. This invention can be brought about by the need for relational progress, but it re-engenders the internal logic of the system [...]. For this reason, internal technical progress can hardly be continuous: it is carried out by leaps and discontinuous stages.[15]

Simondon's analysis arrives at a distinction between two opposed yet complementary principles of evolution: *innovation*, a minor reform that is part of an ongoing process, and *invention*, a major transformation causing discontinuity in the 'technical lineage'. This differentiation matches the general law of the interactions between technique and history previously established by André Leroi-Gourhan in *Milieu et techniques*:

> In the case of a very general phenomenon, one should, in analysing it, uncover both its phases in the detail of each observation and its natural insertion in the entire system of technical Evolution. In other words, the two aspects of slow and meticulous Evolution and sudden Mutation must reappear in each technique and each human group, the same way the partial observation of the phenomena of invention alone should attract an entire network of adherences in the inner surroundings and borrowings.[16]

Leroi-Gourhan is thus stating the fundamental aspect for technique of this historical transformation process through the dual system of (continuous)

14 Gilbert Simondon, *L'Invention dans les techniques*, 101.

15 Ibid, 102-103.

16 André Leroi-Gourhan, André Leroi-Gourhan, *Évolution et techniques*, vol. 2, *Milieu et techniques*, 408.

evolution and (discontinuous) mutation. This quality was further developed in the work of Canguilhem, who recognized technique in 1938 as 'those abrupt changes [and] those fabrications by small variations that are machines and procedures.'[17] These elements underscore the fact that preference for the term innovation, indeed the complete abandonment of the notion of invention, is part of a historiography based on continuity, whereas Simondon's position, in the lineage of French historical epistemology in which it is situated, is clearly based on discontinuity. In the field of art history, Erwin Panofsky also reconsidered the question of 'innovation' in a historiographical context, noting the timorousness of a certain kind of history to acknowledge clear historical ruptures: 'Modern scholarship has become increasingly sceptical of periodization, that is to say, of the division of history in general, and individual historical processes in particular, into what the Oxford Dictionary defines as "distinguishable portions"'.[18]

Here, Panofsky was reacting in particular to an article by George Boas discussing the degree of homogeneity one could attribute to a given period in art history. Boas asserted that whereas for artists of a particular period 'the problems may be common [...]. There will be conflict in the manner in which such problems are solved. Thus [...] the solutions may very well be individual.'[19] I would like to offer a contrary reading: whereas for Boas this observation imposed an art history overwhelmingly continuous in nature – an idea Panofsky refuted – a reconsideration of the epistemological value of *problems* lets us make Boas's proposition the instrument of a history which is, on the contrary, profoundly discontinuous in nature.

We should note in addition that for Leroi-Gourhan a 'sudden change' – an invention – does not fall from the sky, as it takes place in particular through re-appropriation, in a different culture, of a 'borrowing' found elsewhere. On the other hand, and this is crucial for the method itself of 'comparative technology', we can imagine the construction of the history of an entire culture through 'the partial observation of the phenomena of invention alone,' for an understanding of these necessitates or brings about – 'attracts' – the necessary understanding of what he calls 'an entire network of adherences,' which joins the invention and the technical system that produced it. Abrupt and sudden, the change constituting the invention is nonetheless absolutely and entirely historical through and through.

17 Georges Canguilhem, 'Activité technique et création', 506.

18 These are the first sentences in Erwin Panofsky's *Renaissance and Renascences in Western Art*, 1.

19 George Boas, 'Historical Periods', 254.

Innovations and Inventions in Cinema

We must now ask ourselves, in the technical history of cinema, what is an innovation and what may possibly be an invention, and where the most important historical ruptures are located. To view 'sound and talking' cinema as an innovation involves producing a historical and technical continuity between the *dispositifs* 'silent cinema' and 'sound cinema'. We might imagine that cinema's technical, professional, and aesthetic reorganization was sufficient to view 'sound cinema' as having the status of an invention, of a new system whose coherence is founded on principles profoundly different from the former system. At the same time, we should readily grant to 'cinema in colour' the status of invention, that of a completely autonomous *dispositif* with its own history and an origin independent of and prior to that of another *dispositif*, 'black-and-white cinema'.

But major breaks in the history of cinema's techniques should perhaps also be sought outside of general theory and historiography. To paraphrase Febvre, a number of major transformations in the work carried out in each artisanal or industrial trade in cinema in different periods have remained invisible, imperceptible, or unexplained from the outside. I would now like to offer a few examples of this.

Viewfinders and Those Viewed (The Camera Operator's Body 1: The Eye)

The Lumière Cinématographe did not have a viewfinder (Illus. 13). As with a photographic chamber, the operator framed before loading the film with the camera open, through the camera gate and the lens, using a polished surface on which the image appeared. The film was then put in place, the machine was closed, the crank was inserted, and shooting could begin whenever one wished. All these operations, including the shooting, were technically 'blind': the camera operator, beside his machine, could control what was in the frame only by guesswork. During this time, he absolutely could not move his camera. Once the film was in place, there was no longer any way to confirm where the edge of the frame was. To this was added the shape and placing of the crank, which created distance between the operator's body and the camera (or projector) – a distance defined, precisely, by the very shape of the machine, which brought into play not only the operator's gaze, but also his arm.

This configuration of the technical object the Cinématographe was one of a number of contemporaneous procedures in professional or 'amateur'

Illustration 13 – The Lumière Cinématographe (2nd prototype), presented by Charles Moisson. 'Le Cinématographe de MM. Auguste et Louis Lumière', La Nature 1161 (31 August 1895): 216.

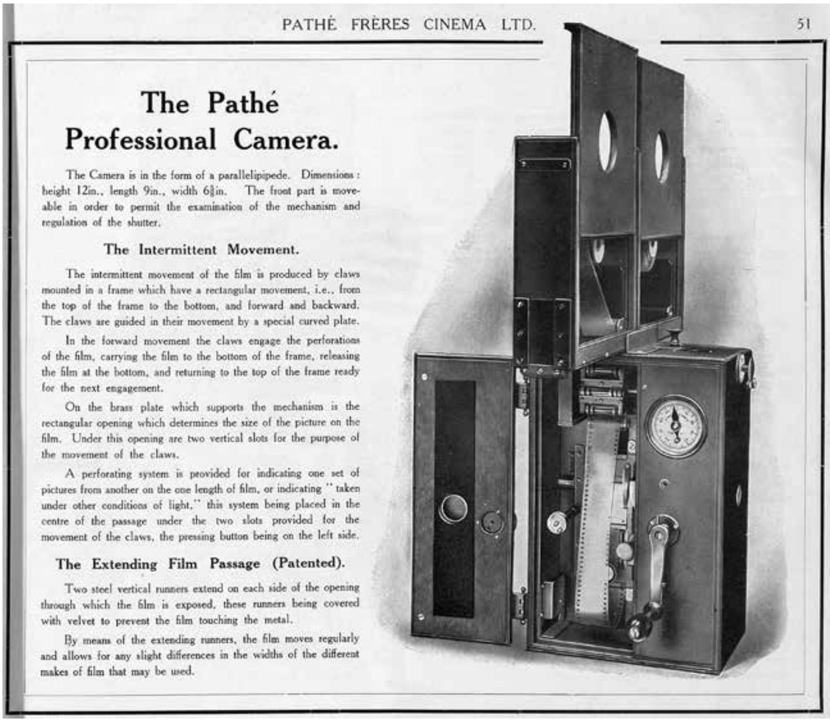
photography, which in Louis Lumière's eyes was the 'target' market for the Cinématographe. Most still cameras of the day did not have viewfinders, although these had begun to appear in various forms. The viewfinder posed a serious technical problem: it had to give the photographer the most accurate idea possible of the framing, but this information had to be obtained without detracting from the picture itself. To this was added the problem of focusing, which I will not address here.

The reflex viewfinder solution was introduced in the 1930s in photography and was gradually adopted to the point of becoming dominant by the 1960s, but not without debate: still today, one of the most expensive and prestigious still cameras on the market, the Leica M series, does not have such a reflex viewfinder. Previous viewfinders were blemished by parallax, and therefore provided only an approximation, depending on the distance of the object being photographed. Framing through the camera gate thus remained the most precise solution, even though it involved a temporal delay between looking through the viewfinder and taking the picture. This delay raised crucial issues in the case of cinema. But they were not enough to push Lumière to put a viewfinder on his machine.

Yet, as we know, Lumière company films, and those shot by Louis Lumière himself before then, show great precision in what he called the 'mise en page' or layout – with respect to both static elements and entrances and exits from the field of vision (or the stubborn absence of these): the visual layout and the organization of the event's duration relative to that of the seventeen-metre-long strip of film. Lumière did not operate through immediate perception of the edge of the frame, but rather through his memory of the boundaries of the field transposed onto the profilmic space, perceived directly with the naked eye. This was a virtuoso exercise, indicative of a singular visual practice.

This absence of a viewfinder may appear to be a major constraint; yet, although amateur movie cameras and newsreel cameras were equipped with viewfinders from a relatively early date, for a long time many professional studio cameras had none, even though this appendage was lightweight, inexpensive to manufacture, and not very cumbersome. The 'professional' Pathé movie camera (Illus. 14) was, as Laurent Mannoni remarks, one of the most widely used in Europe and the United States from 1908 until the 1920s. In particular, it was the camera used by D.W. Griffith's operator, Billy Bitzer; and yet, it had no viewfinder, making its operation similar to that of the Cinématographe, in situations where the demands on the composing of the image were not negligible. Of course, this choice was related to the fact that viewfinders of the day did not let one see the exact framing; but this distance from the operator's eye and body to the camera had important consequences for the kind of view Bitzer could obtain of the profilmic space and the actors, as well as for the relative positions, both physical and hierarchical, of the camera operator and the filmmaker in the concrete space and moment of the film shoot and as part of the film crew.

The arrival of reflex viewfinders in 1937 with the Arriflex 35 and their spread after the Second World War would profoundly modify these practices.



PATHÉ FRÈRES CINEMA LTD. 51

The Pathé Professional Camera.

The Camera is in the form of a parallelipipede. Dimensions: height 12in., length 9in., width 6⅜in. The front part is moveable in order to permit the examination of the mechanism and regulation of the shutter.

The Intermittent Movement.

The intermittent movement of the film is produced by claws mounted in a frame which have a rectangular movement, i.e., from the top of the frame to the bottom, and forward and backward. The claws are guided in their movement by a special curved plate.

In the forward movement the claws engage the perforations of the film, carrying the film to the bottom of the frame, releasing the film at the bottom, and returning to the top of the frame ready for the next engagement.

On the brass plate which supports the mechanism is the rectangular opening which determines the size of the picture on the film. Under this opening are two vertical slots for the purpose of the movement of the claws.

A perforating system is provided for indicating one set of pictures from another on the one length of film, or indicating "taken under other conditions of light," this system being placed in the centre of the passage under the two slots provided for the movement of the claws, the pressing button being on the left side.

The Extending Film Passage (Patented).

Two steel vertical runners extend on each side of the opening through which the film is exposed, these runners being covered with velvet to prevent the film touching the metal.

By means of the extending runners, the film moves regularly and allows for any slight differences in the widths of the different makes of film that may be used.

Illustration 14 – Pathé Professional camera. Catalogue, Pathé Frères Cinema, Ltd. (London), 1915.

From that point on, the camera operator kept his eye fixed to the eyepiece. He could not remove his eye from the camera, as that would let light into it and fog the film. The camera thus got so close to the body of the camera operator that it merged with it, something that would be taken to an extreme with research into lightweight cameras that could be carried on one's shoulder – the Cameflex, Arriflex, Eclair, and later the Aäton. To make a movie camera portable is to conceive the position of its elements in an entirely new way – not just the viewfinder, but also the motor, magazines, batteries, handle, etc. – as the question of balance is crucial. This is an example of innovation through adaptation to the milieu, even if, in the end, the extent of the internal reorganization involved (as well as the procedural and aesthetic reorganization) could very well constitute an invention.

This study must surely be extended by looking at the internal design of viewfinders, the way in which they interact with other elements of the machine, the technical system of which they are a part and its self-correlation. The Arriflex 35 viewfinder was made up of rotating mirrors attached to the shutter; that of the Bolex H16 Reflex, introduced in 1956, functioned by way

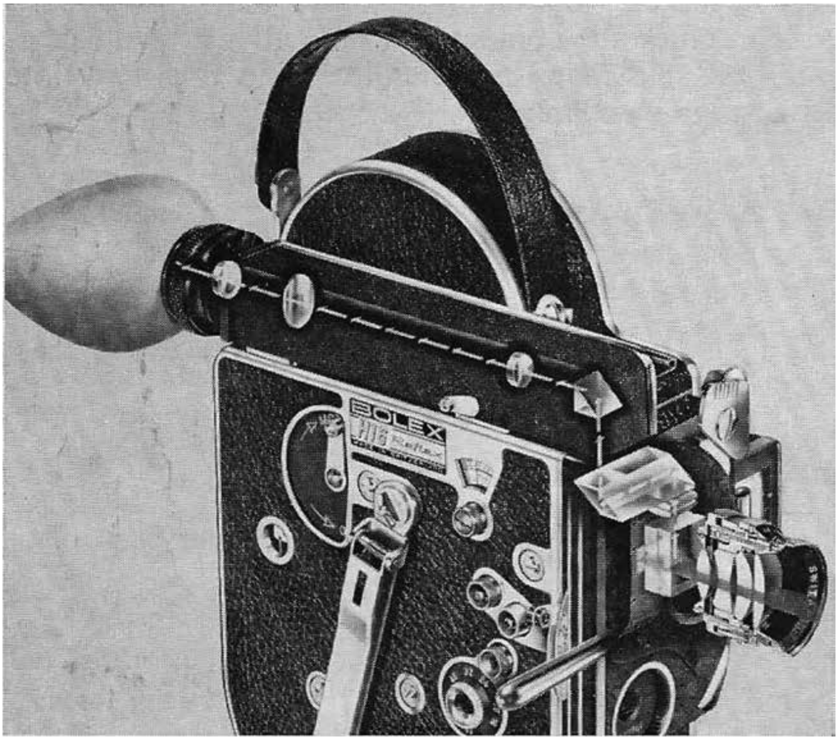


Illustration 15 – Prism reflex viewfinder, Bolex H16 Reflex. Bolex Handbook, 1956.

of a semi-reflective prism (Illus. 15). For the prototype of the Aäton commissioned by Jean-Luc Godard, Jean-Pierre Beauviala created a viewfinder that operated by a semi-transparent blade.[20] These technical decisions involve various issues related to the internal logic of the machine and operational considerations, but also questions of cost, ergonomics, robustness, etc. A mirror viewfinder involves making the shutter heavier and weaker and provides the camera operator with an altered image with a clear flicker caused by a single-blade shutter. A prism or a semi-transparent blade, on the other hand, absorbs a considerable amount of light and makes it necessary to take this into account in setting the diaphragm of the lens, which is not easily interchangeable, a problematic inconvenience in professional use.

In this way, following 'horizontally' the evolution of an element of a machine – the viewfinder – should be done alongside a 'vertical' study seeking to grasp the internal logic of each machine. Technical decisions around the internal organization of a machine are connected to a certain

20 See Jean-Pierre Beauviala and Jean-Luc Godard, 'Genèse d'une caméra (1er épisode)', 99.

idea of how they are supposed to function. An archaeology of these decisions must be established. The mirror reflex viewfinder comes from the photographic *dispositif* of the tilting mirror connected to a curtain shutter; but its movie camera version is more 'concrete', in Simondon's sense of the term, through the re-deployment of the rotating shutter, making not two distinct synchronized devices, but rather a single device with a dual function. The principle, however, is the same: the user can see the precise image through the lens *except at the very moment when the image is exposed*, when the viewer is operating blind, the mirror having shifted position to let light strike the film. 'Like the intervals between heartbeats, what the film sees and what the operator sees is never the same image,' Jean-Pierre Beauviala has written.[21] The practical inconveniences this causes are similar for the photographer and the filmmaker, taking the differences between the two media into account. By extending our study over a longer period of time, we see that the form and history of viewfinders go back directly to Alberti and Dürer's perspective *dispositifs*, some of whose elements are rigorously transposed here. Like those devices designed to help painters construct perspective, viewfinders materialize and fix monocular point of view and mark out the visual field according to a regular, predefined geometric framework. This archaeology, which is only sketched out here, involves observing the circulation and crossover of 'technical lineages', a properly technical and specific form of intermediality.

A viewfinder is a *dispositif* that mediates between the technical object and the milieu, between the machine and the operator. Any conception of the viewfinder is thus immediately tied to a conception of work and the role of the operator. It privileges a certain conception of what a camera operator is. It thereby also involves a conception of the frame, which raises aesthetic questions.

While 'professional' digital movie cameras still have a viewfinder eyepiece, some intermediate models, used in documentary film production in particular, possess also, or only, a screen viewfinder. The operator's eye is thus separated from the camera. The consequences of this transformation are quite important, having to do both with the relation between the body of the operator and the body of the camera and the world around him, on the one hand, and with the connection between filmer and filmed. The French documentary filmmaker Denis Gheerbrant explains that, in a shoot using a traditional movie camera,

21 Ibid.

> At a certain moment [...] I put the camera on my shoulder, I place the eyepiece in front of my right eye, I close my left eye, and the person being filmed is left facing a movie camera and a face whose eyes are closed. We are no longer in the realm of an everyday relation maintained by exchanged glances. We are in a situation that goes beyond us. We each have a specific role. The camera is the spectator between us, and I almost want to say that by closing my eyes I create a space for the spectator, which is paradoxical for a filmmaker![22]

With a screen viewfinder, this role granted to the viewer disappears, or is reworked on entirely different bases.

The screen viewfinder intersects with another history: that of video monitors linked to a film camera; these enable the filmmaker and the crew to view 'live' the image being shot while it is being recorded on the film; this image will be visible only later, when it has been developed and printed in the laboratory. In this way, the *dispositif* 'television' lies at the heart of the 'cinema' production *dispositif*. These video monitors, introduced in the mid-1960s, most notably by Jerry Lewis and then Blake Edwards, profoundly transformed film shoots and in particular the film director's position. Alfred Hitchcock and John Ford sat close to the camera, observing the actors at work directly before their eyes, imagining a final framed image that they would see on the big screen only when the rushes were projected. Filmmakers today, with a few exceptions (Jacques Rivette, Danièle Huillet, and Jean-Marie-Straub), no longer look at the actors, but rather at a television-format image, wearing headphones. The physical distance between the actors and the filmmaker has increased to the point that all direct contact is lost. This has transformed working relations, just as it cannot fail to have transformed the filmmaker's relations with the film's frame and space: the predominance of the establishing shot in films such as John Ford's is tied to a visual imaginary constructed by movie-theatre projection; it may appear more difficult to make a film based on very wide-angle shots if they are viewed during the production on a monitor whose size means that at that scale the actors' expressions will be indiscernible.

In this way, examining the evolution and form of a necessarily modest 'organ' of the cinema machine leads inextricably to procedural and aesthetic implications and thus to an interrogation of the epistemological conditions of the production of the object, of user habits and of the profession's organization, as well as of the cultural issues around the reception of images.

22 Denis Gheerbrant, interview with Catherine Schapira, December 1996, 'La vie est immense et pleine de dangers: Un film de Denis Gheerbrant', n.p.

Editing

In a completely other domain of film work, editing has also been the site of a series of technological transformations with important consequences. The Moviola, the first machine enabling the editor to view moving images at the moment of deciding where to cut them, was invented in 1924. Before then, and for some time afterwards depending on the production context, editing was carried out by working almost solely on the series of fixed images, with cutting decisions later tested in projection. The editor thus had to know how to make a match on the 'intervals of movement' (as Dziga Vertov described them) between photograms. Their work involved a disconnect along with constantly passing back and forth between the editing booth, where one handled the film stock and observed fixed images, and the screening room, the sole place in which to see moving images. In technical terms, the Moviola was not really an invention: it was an adaptation of the projector (intermittent vertical advancement of the film stock, Maltese cross mechanism) to an almost individual viewing machine (back-lit images, projection onto a glass screen). But it overturned things, as editors could now decide where to cut by watching the movement itself – albeit on a small screen. The arrival of 'flatbed' tables, like the Steenbeck in the 1960s, on which the film advanced horizontally, was an interesting innovation: the machine developed independently, distancing itself from the projector model. It took up the mode of uninterrupted advancement seen in Émile Reynaud's Praxinoscope, with its prism of mirrors, making it possible to apply as few mechanical constraints as possible on the fragile 'work print'.

Above all, this machine was contemporaneous with a major transformation: the introduction of adhesive tape to join pieces of film. Previously, when a join was decided, the two pieces of film were joined with cement – a solid bond that would withstand the pulling caused by the intermitted movement in the Moviola and in projection, but impossible to undo. In order to correct the point at which the film was cut, if, when projected, it was deemed the wrong spot, one frame had to be cut away on each side of the join; one thus 'lost' two frames. The margin for error was limited. Because adhesive tape could be removed easily, it enabled editors to try out different matches knowing that they could go back to what they had before without damage. Nevertheless, it had one inconvenience: the tape was visible both on the editing table and when the film was projected, as any viewer from the 'pre-digital' era knows. If one attempted too many shot changes within a few images, it could become difficult to evaluate the success of a match because of the jumps caused by the additional layers of adhesive tape. Even so, this solution was overwhelmingly adopted in editing booths, and brought with it major transformations in editors' practices and in their approach to creating matches.

We might advance the hypothesis that virtual editing – in which one works by computer on files of digitized images and sounds – is, in the end, only a radical technical fulfillment of a mode of work and a conception of the match that were born with the adhesive tape splice. From this point of view, to adopt Simondon's vocabulary, the adhesive tape splice would be the invention and virtual editing the innovation. Of course, this sequence of events does not take into account the evolution of lines of technical objects each deriving from the other in their conception; it does not even follow the transformation of editors' technical methods in the sense of the concrete organization of their working gestures – even though the ergonomics of virtual editing software seeks to transpose as directly as possible that of the 'film' editing booth. But this sequence can bring out the history of editing practices as tied to the evolution of the procedural logic underlying both methods and machines.

For an Epistemology of Machines

The technology of machines should be rounded out by an epistemology of technical decisions, recreating the overall logic of the machines and the technical networks of that they are a part of (these networks are historical, cultural and economic in nature and involve producers, viewers, movie theatres, industries, modes of dissemination, etc.). The internal logic of machines or procedures can thus reveal their unstated suppositions, the paradigms within which the techniques were conceived and utilized. Jacques Guillerme and Jan Sebestik have summed up Christian Wolff's positions justifying the foundation of technology:

> Even a manual art as menial as cutting wood puts into play an implicit conceptual structure which governs the execution of the instruments' operations: 'there is a reason why one can cut wood, and why one can do it with a wedge, and yet just as easily with an axe'.[23]

23 Jacques Guillerme and Jan Sebestik, 'Les Commencements de la technologie', 28.

Here, I will use the expression an *epistemology of machines* to describe research into these 'implicit conceptual structures' shaping machines as individual techniques, as well as integral parts of systems that are also techniques, but also, as a result, historical and cultural systems tied to the conceptual and imaginary realms. These machines have been made possible not only by a certain state of techniques, as Gille suggests, or even by the state of the economy, of society, or of science. They are made possible by these things, but along with this is another constraint or another level, one crucial to an understanding of their coherence, logic, and evolution: the system or conceptual space in which they were conceived or used. Machines are not concepts, nor do they contain concepts; in their individuality, however, each of them puts into play this 'implicit conceptual structure' organizing them.

This epistemology should take into account every aspect of the machine, meaning its form and structure, the technical networks in which it is included, the cultural imaginaries that have forged it and nourish it, and the concrete uses of those who operate it. But it should also be able to disassociate the machine from its concrete and historical uses in order to view it according to its own potentialities. It should be able to envision the machine's historically unrealized uses, its proscribed and devalued uses, and even its never envisioned uses. As Simondon wrote, 'the technical object is never fully known';[24] there always remains within it never-exploited potentialities. In 1967, the Austrian filmmaker Peter Kubelka described what for him was the 'essence of cinema':

> Cinema is not movement. This is the first thing. Cinema is a projection of stills – which means images which do not move – in a very quick rhythm. And you can give the illusion of movement, of course, but this is a special case [...]. You have the possibility to give light a dimension in time. This is the first time since mankind exists that you can really do that.[25]

Kubelka, in addition to being a filmmaker, was a musician, curator, lecturer, and chef; his conception of cinema is tied to the films he made, in which cinema is treated as an art of light-time and *not* as an art of movement. Thus, *Arnulf Rainer* (1958-1960) alternates between black and transparent leader (showing black and then white screens) and between silence and 'white'

24 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, 39.

25 Jonas Mekas, 'Interview with Peter Kubelka'. Reprinted in P. Adams Sitney, ed., *Film Culture Reader* (New York: Cooper Square Press, 2000 [1970]), 291.

noise in an extremely precise rhythm, calculated to the exact photogram. It may be that this conception of cinema is necessary to produce a film such as this; it is also possible that the making of this film produced the conception that made it possible – practice before or after theory, technique before or after science.

Making a film such as this was *technically* possible as early as 1890. But nothing like it was concretely made – at least nothing that has left a trace – or nothing like it was seen as anything other than putting end-to-end scraps of film meant for novice editors to learn the craft, or to test the mechanisms of film equipment. This calculated editing of black-and-white to make a cinematic work was not explicitly prohibited: it quite simply could not be envisioned. It was *epistemologically* impossible, because the 'cinema paradigm'[26] did not include such a possibility. And yet, it is a specific potentiality of the machine, one that may appear not to limit it to its historically determined uses and realizations in a given context.

An Example: An Invention and Its Epistemological Conditions, Wheatstone's Stereoscope

An epistemology of the camera obscura undoubtedly requires that singular machines be situated in a vast cultural history. But another approach to machines could be productive.

The 'stereoscope' was one of the fundamental objects of the nineteenth century and, with Plateau's Phenakisticope and photography, may best symbolize issues around perception. It was clearly a major invention, the source of a technical and cultural lineage of which 3D is still fully a part today. Following an exceptional vogue in photography in the nineteenth century, in the twentieth century 3D veered elsewhere, particularly to cinema, albeit on a considerably smaller scale. Discourse around 3D, and stereoscopy, became institutionalized by presenting the procedure as a profoundly innovative representation of space, calling into question the Western visual tradition, centred on essentially monocular linear perspective.

The stereoscope was invented by Sir Charles Wheatstone (1802-1875), an exemplary and typical intellectual of his century. He made a number of important discoveries and inventions in a wide variety of fields: electricity (with the Wheatstone bridge) and telegraphy, but also musical instrument making – he invented several musical instruments, including the English concertina. He also developed so-called philosophical toys, some of which

26 To use François Albera's expression in 'Le Paradigme cinématographique', 9ff.

were mass produced; one of the first was the Kaleidophone, or Phonic Kaleidoscope, which drew highly pleasing curves with light in response to a sound stimulus. The title of his description of the invention in the *Quarterly Journal* in 1827 is revealing: 'Description of the Kaleidophone, or Phonic Kaleidoscope; a new Philosophical Toy, for the Illustration of several Interesting and Amusing Acoustical and Optical Phenomena.'[27] Philosophical toys were simultaneously experimental protocols, popularizing tools, and children's amusements. In the 1840s, he had a 'Wave Machine' (Illus. 16) built to show visually how two cyclical phenomena were arranged in space. It was still being manufactured and sold in the 1880s, in particular by the Englishman John Newman, a 'Philosophical Instrument Maker'.[28] At the same time, he published a variety of articles, for example 'On the Figures obtained by strewing Sand on Vibrating Surfaces, commonly called Acoustic Figures' in 1833, or his 'Experiments to Measure the Velocity of Electricity and the Duration of Electric Light' in 1834.[29]

In 1838, Wheatstone, then a professor of 'experimental philosophy' at King's College, London, published a text whose importance he recognized. Under the general heading 'Contributions to the Physiology of Vision', the title of Wheatstone's essay demonstrated great assurance of its novelty: 'On some remarkable, and hitherto unobserved, Phenomena of Binocular Vision.'[30] Wheatstone opened his essay by situating himself in the tradition of perspective in order to confirm it *under certain conditions*. This confirmation was formulated in terms of resemblance and illusion: 'when those circumstances which would prevent or disturb the illusion are carefully excluded' – 'hence pictorial representations' of objects 'may be rendered such perfect resemblances of the objects they are intended to represent as

27 Charles Wheatstone, 'Description of the Kaleidophone, or Phonic Kaleidoscope; a new Philosophical Toy, for the Illustration of several Interesting and Amusing Acoustical and Optical Phenomena', 344-351. This device is described by Giusy Pisano in *Une archéologie du cinéma sonore*.

28 See Martin Kemp, *Visualizations: The* Nature *Book of Art and Science*, 66-67. In the early 1850s, Wheatstone and his family posed for a stereoscopic portrait by Antoine Claudet. In it, Wheatstone is seen playing with his 'wave machine'.

29 Charles Wheatstone, 'On the Figures obtained by strewing Sand on Vibrating Surfaces, commonly called Acoustic Figures'; and Charles Wheatstone, 'An Account of Some Experiments to Measure the Velocity of Electricity and the Duration of Electric Light'.

30 Charles Wheatstone, 'Contributions to the Physiology of Vision. — Part the First. On some remarkable, and hitherto unobserved, Phenomena of Binocular Vision'. The essay would be completed fourteen years later: Charles Wheatstone, 'Contributions to the Physiology of Vision. — Part the Second. On some remarkable, and hitherto unobserved, Phenomena of Binocular Vision (continued)'.

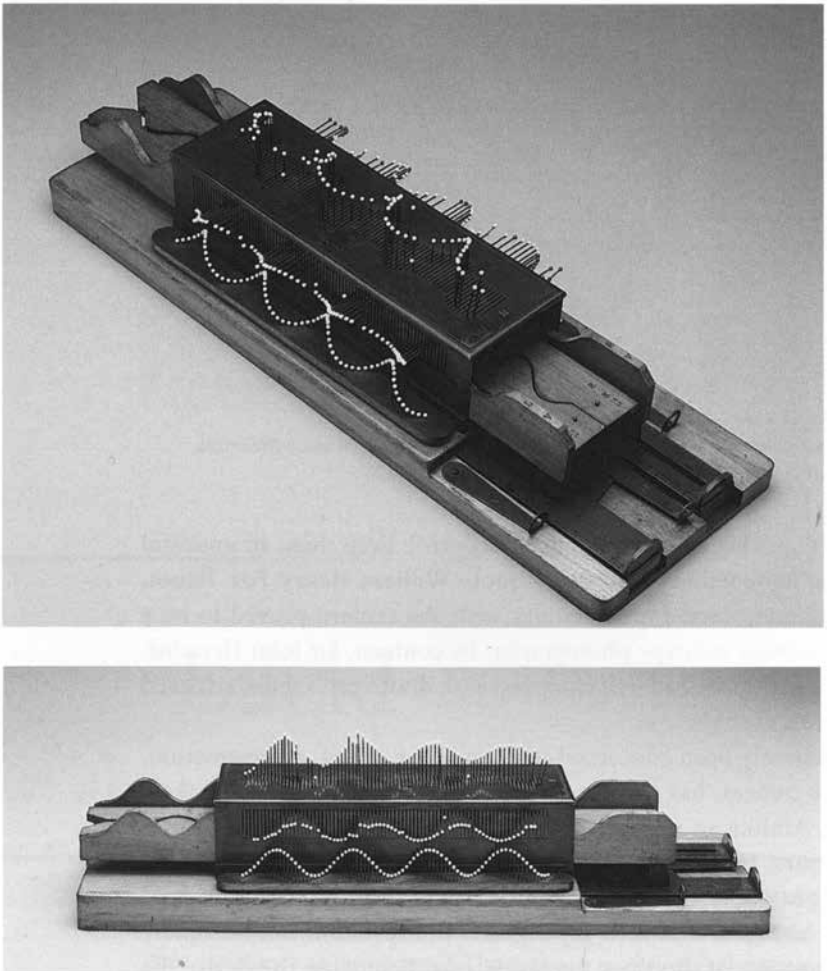


Illustration 16 – Charles Wheatstone's Wave Machine (1840s). From Martin Kemp, Visualizations: The Nature Book of Art and Science.

to be mistaken for them; the Diorama is an instance of this.'[31] What, then, are these conditions? Wheatstone sets them out in the very first sentence of his essay:

> When an object is viewed at so great a distance that the optic[al] axes of both eyes are sensibly parallel when directed towards it, the perspective projections of it, seen by each eye separately, are similar, and the

31 Charles Wheatstone, 'Contributions to the Physiology of Vision. — Part the First', 371.

> appearance to the two eyes is precisely the same as when the object is seen by one eye only.[32]

But if the optical axes converge, because the object is near, then the perspective projections taken from the angle of each of the two eyes differ, and 'it is impossible for the artist to give a faithful representation of any near solid object, that is, to produce a painting which shall not be distinguished in the mind from the object itself.'[33] The simple experiment consisting in placing a cube at medium distance from the face and in looking at it with each eye in turn is enough, Wheatstone explains, to confirm this difference between the ocular 'perspectives'. Wheatstone then remarked on the history of optics and of representation:

> The appearances, which are by this simple experiment rendered so obvious, may be easily inferred from the established laws of perspective; for the same object in relief is, when viewed by a different eye, seen from two points of sight at a distance from each other equal to the line joining the two eyes. Yet they seem to have escaped the attention of every philosopher and artist who has treated of the subjects of vision and perspective. I can ascribe this inattention to a phenomenon leading to the important and curious consequences, which will form the subject of the present communication, only to this circumstance; that the results being contrary to a principle which was very generally maintained by optical writers, viz. that objects can be seen single only when their images fall on corresponding points of the two retinse [*sic*], an hypothesis which will be hereafter discussed, if the consideration ever arose in their minds, it was hastily discarded under the conviction, that if the pictures presented to the two eyes are under certain circumstances dissimilar, their differences must be so small that they need not be taken into account.[34]

After a brief historical survey, principally discussing Leonardo da Vinci as a possible exception, Wheatstone concluded the first part of his essay with the assertion that 'the projection of two obviously dissimilar pictures on the two retinae [*sic*] when a single object is viewed, while the optic[al] axes converge, must therefore be regarded as a new fact in the theory of vision.'[35]

32 Ibid.
33 Ibid., 372.
34 Ibid., 371-372.
35 Ibid., 372-373.

Wheatstone thus established the radical and conscious novelty of his approach and discovery, buttressed by historical and proven research. In substance, it is a theory of representation: that of perspective as an art of illusion, of the impossibility *for the viewer's mind* (and not just their *eye*) to differentiate between image and object. Wheatstone was astounded by this very novelty, given the simplicity of his observation, which required no special technical equipment. It could have been done once the theory of perspective was articulated – in a sense, it even *should have* been: the insistence of these theories on the monocular nature of the procedure called out for this. That it was not done, Wheatstone proposes, was due to *epistemological* reasons. Inattention to the phenomenon that Wheatstone deemed crucial could only be accounted for by the fact that the theoretical paradigm in which these scholars were operating did not tolerate this twist – because then it would no longer be possible to understand how we see every object as a unique entity and not double or triple. They thus learned not to see it.

The perceptible epistemological novelty of Wheatstone's essay lay principally in the scientifically granted status to small differences, to the minute quantities that seem negligible and with which it is difficult to know what to do in a theoretical construction – should one take them into account or not?[36] For an object seen from a great distance, the optical axes will be *nearly* parallel, so that the distance between the points of view of the two eyes can be overlooked; for a near object, however, this becomes impossible. But this boundary can itself only be approximate. In classical optical geometry, these *small differences* – short distances and images virtually the same – had no place; nineteenth-century science was needed in order to take them into account.

We should also note here that, for Wheatstone, the question was never one of space, but rather of the object. Near objects are impossible to paint; the question of the coherence of space does not appear in his work. This is certainly what made possible for him that other novelty, the superimposition on mathematized perspective space of a topology centred on the viewer – a topology that reformulated the construction of space by reintroducing the observer into it through this distinction between near and far (terms themselves marked by approximation).

It was also this formulation, centred on the object, which led Wheatstone to construct a precise experimental *dispositif*, an 'instrument'; he

36 The role of this 'negligible' in science was discussed, from a different angle, by Gaston Bachelard in his principal thesis, *Essai sur la connaissance approchée*.

'propose[d] that it be called a Stereoscope, to indicate its property of representing solid figures.'[37] This device (Illus. 17) was based on a question: 'what would be the visual effect of simultaneously presenting to each eye, instead of the object itself, its projection on a plane surface as it appears to that eye?'[38] The machine was thus constructed to carry out this task, while at the same time solving the problems it brought to light: if the images are shown separately, the eyes will adapt to (focus on) different objects, placed outside the convergence point of the optical axes tied to this distance of adaptation. Wheatstone thus put in place a two-mirror system, each reflecting a frame with the image intended for the right or left eye. The viewer took up a position right in front of the axis of divergence of the two mirrors, each eye seeing only one mirror; the screw joining the axis of the frames and mirrors was constantly adjusted in order to find the distance at which the viewing would be most comfortable, thereby achieving the effect. In the second part of his essay, published in 1852, Wheatstone presented a foldable and portable version of the system, but it was necessarily complex and heavy, difficult to mass produce, etc. David Brewster, in his discussion of Wheatstone's machine in his 1856 volume on the stereoscope, made a list of its 'imperfections'. The first was that it was a 'clumsy and unmanageable apparatus, rather than an instrument for general use.'[39] Brewster then described his own stereoscope (Illus. 18), using refraction (through lenses) rather than reflection, which was easier to manufacture, to use, and to sell. These machines nevertheless imposed standardized image sizes, something that was not true of Wheatstone's reflective stereoscope, an important aspect of his experimental project. But once this standard format became economically dominant, the compatibility of Brewster's stereoscope with it and the incompatibility of Wheatstone's model became one more argument in favour of the former.[40] In Wheatstone's mind, the use of his machine was in itself pedagogical, even if this aspect could involve a degree of complexity of use (which, in the event, was not considerable).

We thus see, in Wheatstone himself, and then in Brewster, Jules Duboscq (Illus. 19), Oliver Wendell Holmes, Theodore Brown, and many others, a

37 Charles Wheatstone, 'Contributions to the Physiology of Vision. — Part the First', 374.

38 Ibid., 373.

39 David Brewster, *The Stereoscope: Its History, Theory and Construction; With Its Application to the Fine and Useful Arts and to Education*, 62.

40 Brewster would employ the device beginning in 1856 in ibid., 63: 'The reflecting stereoscope is inapplicable to the beautiful binocular slides which are now being taken for the lenticular stereoscope in every part of the world'.

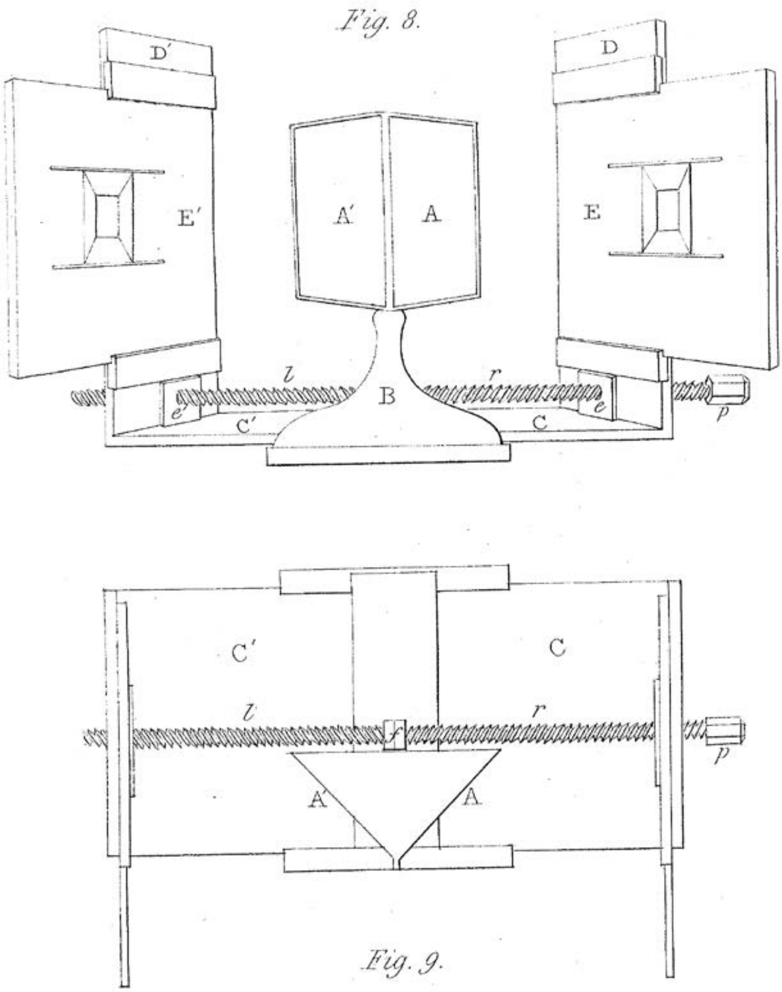


Illustration 17 – Charles Wheatstone's Stereoscope. Front and top diagrams. Wheatstone, 'Contributions to the Physiology of Vision.—Part the First', Philosophical Transactions of the Royal Society of London, 1838.

technical, instrumental, industrial, and commercial way of thinking that took the device through a series of transformations of varying importance, on bases that defined from the outset a broad or limited usage, a compromise between optical quality and cost, etc. Wheatstone's original instrument had initially been an experimental procedure. It then became, for the 1838 publication, a demonstration *dispositif* with the goal of illustrating his

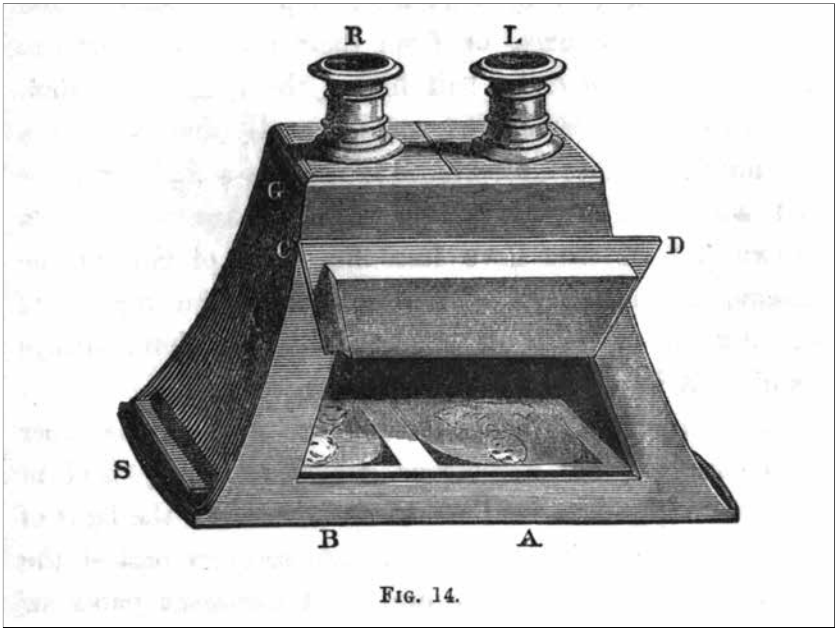


Illustration 18 – David Brewster's Stereoscope with lens. The Stereoscope: Its History, Theory and Construction, 1856.

discovery, a discovery that was above all theoretical (and epistemological) in nature and that became embodied in his machine. This primitive machine, conceived as part of a particular project, would go on to become a conceptually autonomous technical object and thus evolve into a line of objects, each different from the last in a number of respects even though their fundamental principle remained the same, thereby guaranteeing the cohesion of the term 'stereoscope'.

We must emphasize this point: the stereoscope as machine was a major invention that, properly speaking, had no new technical element. All its elements were technically old, very old even: it was nothing more than a clever arrangement of mirrors and, later, lenses. This did not prevent in any way the absolutely new nature of the device, and thus its status as an invention. Its novelty was strictly epistemological, having to do with the 'hitherto unobserved' Wheatstone proclaimed in 1838. These 'contributions to the physiology of vision' were made possible by a number of epistemological conditions that appear to have been new: the possibility of an apt theoretical consideration of the *small difference* and the *negligible*. It is not clear that we can attribute these epistemological novelties to Wheatstone himself, but whatever the case, the form he gave them was

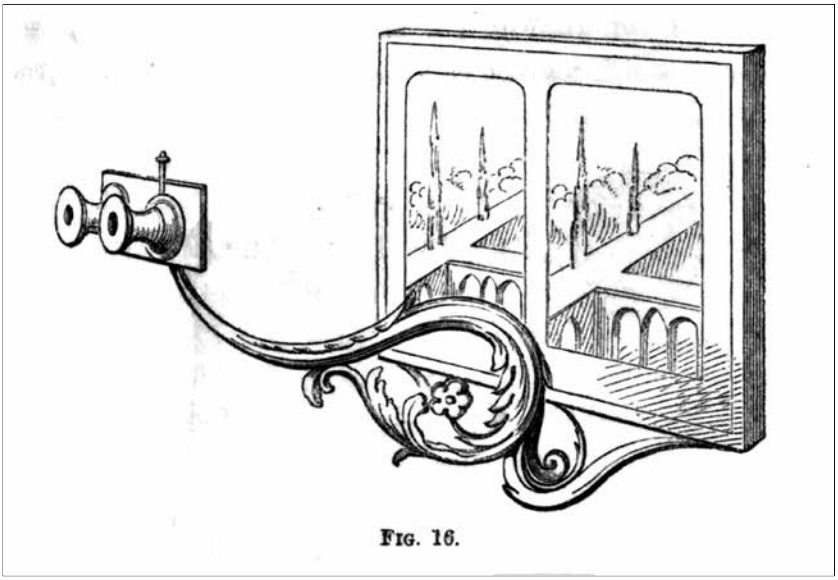


Illustration 19 – Jules Duboscq's Stereoscope with lens. In David Brewster, The Stereoscope: Its History, Theory and Construction, 1856.

an incontestable rupture. This status of the small difference and the subject/space relation involved in his device's topological play are some of the crucial elements of the 'implicit conceptual structure' tied to the stereoscope.

3. The Invention of the Problem

Abstract
The epistemological approach to film technology is further developed through the study of a key moment: the first patents and projects describing some sort of 'cinema' machines as early as the 1860s. Discussing the place of these within media historiography (Sadoul, Bazin, Frizot, etc.), two of these apparatuses are analysed in their context with the greatest possible precision. Approached through the combined perspectives of Simondon, Bachelard, and Canguilhem, they allow the construction of the concept of 'problem', which is central to an epistemology of machines.

Keywords: Invention, media history, Gilbert Simondon, Gaston Bachelard, Charles Cros, Louis Ducos du Hauron.

The Idea and the Question of Origins: André Bazin as Historiographer

'The Myth of Total Cinema' constitutes André Bazin's incursion into the writing of film history and historiographical methodology. I refer to the 1958 version of the essay included in *What is Cinema?*, not the original article published in *Critique* in 1946, entitled 'The Myth of Total Cinema and the Origins of the Cinématographe'.[1] The 1946 book review was radically different from the rewritten text of 1958: in 1946, Bazin more timidly stuck to writing an interesting but often approximate summary of the book he was reviewing by Georges Sadoul, in the end forming his own hypothesis only unobtrusively. Relations between the critic Bazin and the historian Sadoul were quite simply more respectful in 1946 than they were twelve years later, when Bazin extensively revised the text. In that version, the historiographical criticism absent in 1946 revealed the more complex relations between the men in 1958.

1 André Bazin, 'Le Mythe du cinéma total et les origines du cinématographe'.

Turquety, B., *Inventing Cinema: Machines, Gestures, and Media History*. Amsterdam: Amsterdam University Press, 2019.
DOI 10.5117/9789463724623_CH03

Placed by Bazin right after 'Ontology of the Photographic Image' in the first volume of his 'summa', 'The Myth of Total Cinema' appears to the reader as the historicized – and amused – pendant to the theoretical, ahistorical, anthropological, and highly serious opening text. The article is certainly among the better known of Bazin's texts, whose principal argument can be summarized by this remark:

> The guiding myth of the invention of cinema is thus that it will accomplish the dominant myth of every nineteenth-century technique for reproducing reality, from photography to the phonograph: a complete realism, the recreation of the world in its own image – an image upon which the irreversibility of time and the artist's interpretation do not weigh.[2]

According to Bazin, this fundamental guiding myth has inflected the entire history of the medium, a history that will only be complete when it finally achieves this total cinema, as described by René Barjavel in his book *Cinéma total: Essai sur les formes futures du cinéma* of 1944, which Bazin alludes to in his text in several ways without naming explicitly.[3] This text is undoubtedly that which most clearly expresses Bazin's messianic approach: a conception of historical becoming that gradually accomplishes the essence of his object of study, reaching its conclusion when it appeases the medium's initial promise. Barjavel had already posited the idea of such a 'constant evolution' leading cinema to a 'perfect state. Total cinema': the end of history.

The amusing part – what clearly amused Bazin in 1958[4] but did not appear at all in 1946 – is that this hypothesis justifying and liquidating history is formulated as the conclusion to be drawn from reading 'Georges Sadoul's admirable new book on the origins of cinema', the first volume of his *Histoire générale du cinéma*, whose first edition came out in 1946.[5] It is

2 André Bazin, 'The Myth of Total Cinema', 17. (Translation modified slightly – Trans.) This passage also appears in the earlier version of the essay. See 'The Myth of Total Cinema and the Origins of the Cinématographe', 36.

3 In addition to the title, we could mention for example Bazin's remark that 'cinema has yet to be invented!' ('The Myth of Total Cinema' [1958 version], 17), which echoes Barjavel's 'cinema does not yet exist'. See René Barjavel, *Cinéma total: Essai sur les formes futures du cinéma*, 10.

4 Tom Gunning, in his contribution to the *Opening Bazin*, describes Bazin 'somewhat perversely' offering 'a highly ironic approach to Sadoul's book' (p. 120). See Gunning, 'The World in Its Own Image: The Myth of Total Cinema'.

5 Georges Sadoul, *Histoire générale du cinéma*, vol. 1, *L'invention du cinéma, 1832-1897*.

already noteworthy that Bazin constantly describes the book as investigating cinema's 'origins', when Sadoul prefers the more materialist term 'invention'.

What is juicy about the affair is that, here, Bazin corrects the historian Sadoul not merely on a particular aesthetic appreciation that caught the critic's eye, or on a particular historical point, but rather, and more seriously, on the ideological coherence of his historical method:

> What Georges Sadoul's admirable new book on the origins of cinema has revealed is the paradoxical feeling that the relationship between economic and technical developments on the one hand and the imagination of cinema's inventors on the other has been inverted, despite the author's Marxist beliefs. It seems to me that in this instance we need to [...] view fundamental technological discoveries as fortunate and propitious accidents essentially secondary to the initial conceptions of cinema's inventors.[6]

In this opening sentence of the entirely new text of 1958, for which there is no equivalent in the 1946 book review,[7] Bazin takes impish pleasure, hiding behind his praise for the book as 'admirable', in describing a 'feeling': what the Marxist historical method has 'revealed', like a latent image, is precisely that 'cinema is an idealist phenomenon.' In the end, then, Sadoul showed Bazin the profoundly timeless and ahistorical nature of cinema – or the idea of cinema – unfettered by the economic, political, and technical circumstances of its materialization.

Yet, throughout the book review Bazin sticks fairly closely to Sadoul's text. When Bazin wonders at the disconcerting existence of cinema's 'precursors', who were 'more like prophets',[8] he is only adopting the vocabulary of Sadoul's book, whose third chapter is entitled 'Cinema's Prophets'. This initial section of Sadoul's book, after discussing Joseph Plateau (who 'laid down cinema's principles', as the title of the first chapter describes it), is concerned with what we might call the 'first wave' of research into moving images – at first drawn and then photographic – in the 1850s and 60s in the hands of Duboscq, Du Mont, Cook and Bonelli, Ducos du Hauron, etc. Indeed, in this discussion Sadoul does give the 'feeling' of being profoundly

6 André Bazin, 'The Myth of Total Cinema' (1958 version), 13. (Translation modified slightly – Trans.)

7 'In this large volume, Georges Sadoul has succeeded in preserving the clarity and interest of his story without sacrificing scholarly accuracy'. 'The Myth of Total Cinema' (1946 version), 31.

8 André Bazin, 'The Myth of Total Cinema' (1958 version), 15.

impressed by the historical disjunction he notes, finding these men to have formulated projects or ideas he sees as extraordinarily close to what would be only concretely realized 30 or 40 years later. He endows Du Mont with 'remarkable prescience' and Ducos with 'astounding precision [...] forty years ahead of his time,' as well as with the ability to 'foresee some of cinema's most remarkable applications.' Ducos was 'prophetic' in the way he 'anticipated [things which] foretold the film'. 'Some of his contemporaries, known or unknown to us, foresaw the same future cinema.'[9] 'Thus,' Sadoul concludes, 'technique, like economics, was an obstacle to the realization of the moving photographs of which remarkable men of foresight had already caught a glimpse.'[10]

What Sadoul states here is not the same as Bazin's messianism, nor does it share his ontological and idealist premises – already the intrusion of economics has made Bazin's idealist formulations more prosaic and complex. In a contemporary text brought to light by François Albera, Sadoul even made formal in quite precise terms the complexity of this historical connection between technical invention and society through the notion of 'social control'.[11] Here are crystallized all the non-technical conditions, i.e. economic and especially cultural conditions, of an innovation's dissemination at a given point in time. This notion derives fairly clearly from a Marxist approach to the history of technics, but it is true that the 'paradox' identified by Bazin seems to reappear at the heart of this first volume of *Histoire générale du cinéma* in Sadoul's astonishment at the obstinacy and curious resistance of facts to the method. Sadoul's insistence on the intriguing nature of these historical echoes would be resolved by Bazin, and by most of the subsequent readings of Sadoul, by concluding that the Marxist historian had constructed a linear and teleological history whose method was in conflict with his political conceptions.

It was against this conception of history attributed to Sadoul (and others) as a 'coherent narrative of technical progress' and 'inherently teleological,'

9 Georges Sadoul, *Histoire générale du cinéma*, vol. 1, 36-38.

10 Ibid., 42.

11 Georges Sadoul, 'Pour le cinquantième anniversaire de l'invention du cinéma (1895-1945): Les premiers pas du cinéma', 78. Quoted by François Albera in '1945: trois "intrigues" de Georges Sadoul', 61. This article also explores the breadth of Sadoul's methodological work before and during the war around this initial volume (pp. 54-61) and situates it in this context of Bazin's book review in *Critique* and the different version found in *What is Cinema?* (pp. 61-64). Valérie Vignaux revisited Sadoul's historiographical methodology in 'Georges Sadoul et l'Institut de filmologie: des sources pour instruire l'histoire du cinéma.'

as Tom Gunning points out,[12] that the post-Brighton conference historians took up position after 1978 (Gunning mentions, in addition to himself, personalities as different as Charles Musser, André Gaudreault, Jonathan Crary, Laurent Mannoni, Deac Rossell, and Michael Chanan[13]). According to this American film theorist, what the diverse forms of this 'new history' share is that they all 'draw directly or indirectly on the historical methods of dialectical materialism.'[14] Bazin and the post-Brighton historians reproach Sadoul for the same thing: not his 'Marxist point of view', but rather the absence of Marxism in his method. Gunning thus ends up, rather bizarrely, identifying Bazin, despite the contrasting approach Gunning remarks, as 'prescient of the more recent archaeology of cinema,' even 'anticipat[ing]' in some respects 'themes crucial to later scholars.'[15] Here, Gunning adopts the teleological vocabulary he wishes to ban. Bazin's clever book review, broadly oriented by extra-historiographical issues, finally established in 1958[16] an orthodox reading of Sadoul on this question, one which would prevail. Whereas this understanding of Sadoul the communist historian is a good description of certain aspects of his historical construction, what initially struck Sadoul himself, and Bazin also, eludes that traditional reading: astonishment.

The Idea and the Question of Origins: After Photography

These questions echo François Brunet's recent research into 'the birth of the idea of photography'. This historian, working outside 'cinema studies', remains unconcerned with the categorizations based on the fateful date of the International Federation of Film Archives congress in Brighton in 1978. In the historiography of photography, Brunet describes a movement whose similarities with the Bazinian moment are striking:

> [The] encyclopaedic quest for [photography's] origins has tended to define the invention of photography or the project underlying it as the translation of a timeless 'dream', an anthropological archetype: that of a natural image of mysterious origins which is not the product of human

12 Tom Gunning, 'The World in Its Own Image', 121.

13 Ibid.

14 Ibid. The degree of this engagement with dialectical materialism varies according to author.

15 Ibid., 121-22.

16 And not in 1946, as the version of the article in *Critique* does not contain this aspect.

> intervention, the image of the myth of Butades and that of the Shroud of Turin, meaning the *a-technical* image. This profoundly idealist or even theological image has weighed heavily on the direction historiography has taken and even on the theory of photography [...]. A dream or an idea, this image has for all time guided thinkers' imaginations, thereby dominating, like an abstract universal, the series of concrete historical materializations.[17]

Brunet never mentions Bazin in his book, but does reference Georges Potonniée's *Histoire de la découverte de la photographie* (1925) as an example of a history founded on a hypothesis that 'consists in advancing an "idea of photography" existing prior to its invention.'[18] Sadoul also quotes Potonniée, but in this case the latter's volume *Les Origines du cinématographe* (1928); moreover, he criticizes Potonniée's overly simplistic teleological vision.[19] Bazin takes up the reference in his article, without distancing himself from it like Sadoul. His 'Ontology of the Photographic Image' and 'The Myth of Total Cinema' are seen here to be rooted in a powerful theoretical tradition.[20]

The critique of the teleology framing the historical study of 'pre-cinema' has been formulated by another historian of photography, Michel Frizot, in a chapter maliciously entitled 'The Historiography of Illusion' of his most recent book on Étienne-Jules Marey:

> The false 'culmination' in the *Cinématographe*, which was by no means a definitive term in 1895, is generally understood as the search for a solution to a general problem which, in fact, was never stated: the making concrete of the most satisfying imitation possible of perceptible reality [...]. This history concerns a wide range of 'technical objects', instruments

17 François Brunet, *La Naissance de l'idée de photographie*, 31.

18 Ibid., 33-34.

19 Georges Sadoul, *Histoire générale du cinéma*, vol. 1, 29 (the two volumes by Potonniée are mentioned by Sadoul in the bibliography to chapter two, 'La Photographie s'anime', p. 33). André Bazin, 'The Myth of Total Cinema' (1958 version), 16. (Bazin mentions 'a film historian, P. Potoniée [*sic*]', and provides exactly the same quotation as Sadoul, without noting his source. [Georges Potonniée's name was corrected in the English translation quoted – Trans.]). See Georges Potonniée, *Histoire de la découverte de la photographie*; and *Les Origines du cinématographe*.

20 In addition, François Albera has shown the extent to which this tendency to '"project" the cinema into a technological future' on similar conceptual bases has been frequent in the history of its reception since cinema's beginnings and pertains to its own 'episteme'. See 'Le Paradigme cinématographique', 31.

> conceived of as unique and exclusive entities, none of which has the same structures and none producing the same effects. It is thus not possible to present this history as linear with an end in itself.[21]

I can only heartily endorse Michel Frizot's views. It is in this framework, moreover, that a history of technics, seen as an archaeology of machines and an epistemology of *dispositifs*,[22] should make possible an understanding of the precise singularity of each device, in its structure, its form, the premises of its conception and its real or promised results.

It remains, however, that whereas this linearity is unthinkable, the atomization of this history into constellations of entirely autonomous singularities would not be entirely satisfactory either. It would not make it possible, for example, to grasp what exactly caused Sadoul's astonishment: the absolutely contemporaneous inventions mere kilometres apart, the amazingly precise formulations of propositions that would only be carried out years later.

One may see, however, or construct, ambiguity in the quotation of Michel Frizot above. If the proliferation of optical machines in the nineteenth century was not 'the search for a solution to a general problem which, in fact, was never stated: the making concrete of the most satisfying imitation possible of perceptible reality' – a proposition which articulates Bazin's version of history – should we conclude that there exists no 'general problem', formulated more or less explicitly, to which some of these machines could be seen as searching for the solution?

Frizot himself, moreover, had already nuanced this position. In his chapter 'Speed of Photography: Movement and Duration', in his edited volume *A New History of Photography*, originally published in French in 1994, he was careful to clearly separate the research of Eadweard Muybridge and his contemporaries from any kind of 'cinematographic' project. In order to do so he established a distinction:

> This type of experiment is generally linked to the invention of the cinema (nearly twenty years later), but that is a pseudo-historical view of events, directed by hindsight, and does not correspond to the real objectives of

21 Michel Frizot, *Étienne-Jules Marey chronophotographe*, 256. The quotation marks around the expression 'technical objects' implies a reference to Gilbert Simondon which is never made clear.

22 On this topic, I take the liberty of referring the reader to my articles 'Forms of Machines, Forms of Movement'; and 'Pour une archéologie des techniques cinématographiques: L'exemple du Kinemacolor'.

> the protagonists of the decisive years 1875-1885, since none of them had looked for, or even envisioned, that reconstitution of visual reality that we call cinema. On the other hand, other practitioner-theoreticians had taken a real interest in this problem. People such as Louis Ducos de Hauron (1864), Cook and Bonelli (1863-1865) and Henry Du Mont, who wrote in his patent of 1861: 'People in motion will be reproduced in all the phases of their movements and with the interval of time which really separated those phases'. Because the technology was not yet up to it, all these projects, viable in conception, remained mere theories, awaiting the possibility of the production of real instantaneous pictures of adequate speed.[23]

This passage articulates a historical periodization and a theoretical claim. Frizot sees two distinct moments: on the one hand, the 'decisive years 1875-1885,' during which it seems, to him, necessary and easy to make a radical separation between the 'real objectives of the protagonists' and 'what we call cinema.' On the other hand is an older period, located by a few projects in the first half of the 1860s, when, on the contrary, researchers 'had taken a real interest in this problem.' When he examined the exact moment and the precise work that had given rise to Sadoul's surprise, therefore, Frizot meets Sadoul's argument precisely: the complete likeness of the problem, its conscious and precise formulation, and its non-materialization due purely to technics 'not being up to it.'[24]

There was thus a 'problem' defined explicitly according to the terms of what would become the 'cinema' – meaning, and here the theoretical proposition structuring the argument is formulated, 'that reconstitution of visual reality that we call cinema' – posed as an object of research for several scholars in the 1850s and 60s but that would later disappear during the 'decisive years' before finally returning in the articulation of the 1890s – or later? To view researchers from the second period from the perspective of 'cinema' is a major historiographical error, part of a 'pseudo-historical view of events, directed by hindsight.' The previous period, however, in both Frizot and Sadoul – and to Bazin's delight – appears to resist this historiographical notion, one nonetheless strongly asserted.

23 Michel Frizot, 'Speed of Photography: Movement and Duration'.

24 Sadoul writes: 'The unfortunate thing is that photographic technique of the day made it impossible for them to see how their cameras worked in a satisfactory manner' (*Histoire générale du cinéma*, vol. 1, 38). This argument is of course crucial to Bazin's demonstration: 'The earliest films did not have all the attributes of tomorrow's total cinema, but not for lack of trying; it was only because their fairies were technically powerless to endow them with such attributes, despite their desire to do so'. André Bazin, 'The Myth of Total Cinema' (1958 version), 17.

The Invention and Evolution of Problems: Simondon with Bachelard

How, then, are we to understand this historical connection? On what bases would it be possible to test the periodizations proposed, the true continuities and ruptures?

In the end, the question is whether the *problem* each of these inventors asked themselves corresponds more or less exactly with 'what we call cinema'. For, and this is the hypothesis I wish to advance here, it truly is the notion *problem* that is relevant in this context.

In fact, Gilbert Simondon, in his complementary thesis of 1958, *On the Mode of Existence of Technical Objects*, had described an invention as the 'resolution of a problem.'[25] For Simondon, moreover, this notion had a very broad scope, because it concerned the phenomenon of individuation as a whole, thereby also playing a key role in his principal thesis, *L'Individuation à la lumière des notions de forme et d'information*. As Gilles Deleuze remarked: 'In Simondon's thought, the category of the "problematic" takes on great importance [...]. Individuation is thus the organization of a solution, of a "resolution", for an objectively problematic system'.[26]

To return more precisely to inventions, however, the simplicity of the formulation refers to a complex, collective, and historical process through which a technical object is individualized over the course of a specific genesis, which Simondon conceptualizes as an alternation of 'concretization' and differentiation. The evolution of technical objects is thus made up of an arrangement of abstract phases and tensions towards concretization, of adaptation to the surroundings and of internal reconstructions, and of minor innovations that introduce abrupt transformations representing discontinuity in the historical evolution of the object.

His definition of an invention as the resolution of a problem supposes that a problem pre-exists the invention. We might imagine that this anteriority takes several forms: a conscious problem pre-existing the entirety of the research and motivating it; a problem formulated after the fortuitous discovery of a new phenomena and made clear in order to describe the contribution of the procedure to obtain a patent, etc. For

25 Gilbert Simondon, *L'Invention dans les techniques: Cours et conferences*, 102-103 and 276.

26 Gilles Deleuze, 'Gilbert Simondon, *L'Individu et sa genese physico-biologique*'. Reprinted in Deleuze, *L'Île déserte et autres textes: Textes et entretiens 1953-1974*, 122. The book Deleuze read was a partial publication, in 1964, of Simondon's dissertation. In addition, in 1974, Simondon gave a course entitled 'La Résolution des problèmes', excerpts from which were published in *L'Invention dans les techniques*, 305-325.

Simondon, however, an invention exists only as the resolution of something that appears as a problem at a given moment; there is, Jean-Yves Chateau has written, a 'form of the *problem*' that is 'characteristic of the situation of invention.'[27]

This theory of Simondon's on the genesis of technical objects intersects with another, one Simondon was probably familiar with, even though he does not mention it: Gaston Bachelard's description of the evolution of problems in the sciences. According to Georges Canguilhem, Bachelard's complementary thesis defended in 1927, *Étude sur l'évolution d'un problème de physique: La propagation thermique dans les solides*, was 'a study in science history, but in a truly new sense.'[28] From the outset, the volume laid out a powerful hypothesis:

> It is easy to think that scientific problems succeed one another historically by order of increasing complexity, without always making the effort to rethink the problem as it appeared to its early observers and without defining in what ways a problem is held to be complex. We forget that the solution found reflects its clarity on the facts, contributes schema which simplify and direct the experiment and that the partial solution coordinates with a general system from which it draws additional strength.[29]

The novelty consists, primarily, of envisioning not a history of scientific ideas or systems, but rather a history of problems. This initial reversal brings with it another, which is historic – and typical of Bachelard, in that from the outset it runs counter to common sense: the observation that real historic order is not what intuition would suggest. The history of science does not go from the simple to the complex, but from the complex to the simple. The implied equivalence between 'simple' and 'clear' in Bachelard's passage can be seen as ultimately rooted in a more classical epistemology. As Canguilhem summed the matter up, 'the *initial* phenomenon of the research is not *initially* a simple phenomenon.'[30]

27 Jean-Yves Chateau, 'L'Invention dans les techniques selon Gilbert Simondon', 29. Emphasis in the original.

28 Georges Canguilhem, 'L'Histoire des sciences dans l'oeuvre épistémologique de Gaston Bachelard', 174.

29 Gaston Bachelard, *Étude sur l'évolution d'un probleme de physique: La propagation thermique dans les solides*, 7.

30 Georges Canguilhem, 'L'Histoire des sciences dans l'œuvre épistémologique de Gaston Bachelard', 174. Emphasis in the original.

The reason the concept *problem* is productive is that it is at once and inseparably historical and effectual. It is exactly that with which the scientist works – or, Simondon would say, the technician. Here, for example, is how Louis Lumière was able to formulate his contribution in his article for the *Journal of the Society of Motion Picture Engineers* in 1936:

> When the Edison Kinetoscope appeared in Paris in 1894 in a shop on the boulevards, there were many who thought, after having peered into the eyepiece of this ingenious device, that the projection of the moving images, which were produced then for only one spectator at a time, would be of considerable interest [...]. My brother and I decided to investigate the problem [...].[31]

In a letter to Georges Sadoul, the term would reappear with respect to his folioscope system, the Kinora, patented on 10 September 1896:

> *I never intended* [with this device] *to compete with the Edison Kinetoscope*, but rather simply to resolve an interesting problem with which I had been confronted. *I also had no mercantile objective* [...].
> The device I baptized the *Kinora* was simply a way of correctly using the paper prints of my negatives. It made it possible to view the images in a perfectly sharp manner, something achieved by none of the numerous *dispositifs* in the form of notebooks, which one used by making the images advance by flipping through the notebook with one's thumb.[32]

Lumière describes the resolution of 'an interesting problem with which I had been confronted' as a pure and disinterested activity of technical invention. The problem here is that existing systems did not provide a 'perfectly sharp' view of the images when one (individually) viewed the pictures in the form of a series of paper prints. Lumière thus produced a mechanism that was an improvement or 'innovation' with respect to these systems, making it possible to use these prints 'correctly'.

The term *problem* was also what was used by Albert Londe when, in 1896, he described the contributions of Étienne-Jules Marey and Georges

31 Louis Lumière, 'The Lumière Cinematograph'. Reprinted in Raymond Fielding, *A Technological History of Motion Pictures*, 49. It should be noted that this article is one of the rare occasions when Lumière granted such an important role to Edison's Kinetoscope.

32 Quoted by Georges Sadoul in the revised 1948 edition of his book, 213. Emphasis in the original.

Demenÿ, before Lumière: 'The solution to the problem was very simple. One only had to use for the projection a device identical to that which was used to take the pictures, meaning which stopped momentarily after each image'.[33]

The epistemology of a machine must be elaborated, on the basis of an examination of the technical object's coherence and genesis, by (re)constructing the specific problem for which it presents itself as the solution. The coherence of Wheatstone's reflective stereoscope lay in what *precisely* was its inventor's problem, meaning not an overall calling into question of perspective representation, or a new conception of space, but more precisely the resolution of what constituted, in a certain model of representation, a technical limit to perspective: the particular case of *near, solid objects*. It was to address this problem that the machine was developed. Later, stereoscopes – those by Brewster and others – took up the fundamental principle of the device, but their structure was different, because the problems organizing them were no longer the same.

Problems do not exist on a purely theoretical plane, but are arranged concretely into a series of gestures: the observation (and even the construction) of the data, the establishment of schema, the setting up of experimental protocols, and the construction of machines. Each is dependent on successive epistemological systems attached to them by 'networks of adherences', to employ André Leroi-Gourhan's vocabulary. The evolution of problems can thus be analysed through the study of the succession of experiments, as Bachelard remarks:

> Nevertheless, as often happens, the complex experiment was found to provide the most precise and fine-grained illustration of the simplest experiment. Once again, we see that the historical order does not necessarily follow the line best adapted to discovery. It is afterwards that one understands the true hierarchy of problems.[34]

The problem and the experiment – the form of the problem, and the form of the experiment – are thus connected in a dialectic of the simple and the complex that makes up historical movement. Science will then take it upon itself to reconstruct, after the fact, this history in the aftermath of the

33 Albert Londe, *L'Industrie progressive*. Quoted by Georges Sadoul, ibid., 217.

34 Gaston Bachelard, *Étude sur l'évolution*, 94.

solution that was found and understood. The 'right' experiment, the 'right' machine, the 'right' concepts, re-orient the whole sinuous path leading to them and will make it possible to define – in accordance with them – what is simple and what is complex.

The problem – and not the idea – is key. This is why an invention can be a resolution of the problem. But if an invention is a resolution of the problem, it is also because identifying a problem and its position are fundamentally a form of invention. Bachelard writes:

> In fact, to contribute to progress in the mathematical sciences we need problems more than we need solutions. For the problem is the first trace of the mathematically new fact. But in order to pose correct, connected and new questions, reality is as productive as the imagination. It suggests and coordinates.[35]

Technics intervenes here as experiment and as reality: it is what will pose a problem, or rather what poses the problem's conditions, which must then be given form through hypotheses, by restricting or broadening the framework, etc.

Bachelard's orientation towards the problem and its position brings with it new interest in the initial phase of its appearance, when it constitutes the 'first trace of the new fact' – a phase often neglected by the traditional historiography of the sciences because it is a phase of mistaken methods, erroneous concepts, and unsophisticated experiments, wrong directions built on epistemological suppositions seen as out of date or absurd precisely because the solution, once found, made them obsolete. Canguilhem sums up this initial phase of the problem as 'that in which one believes one is explaining a phenomenon by alternating analogies one after the other once the experiment makes it necessary to change tack.'[36]

According to Bachelard, a problem cannot be posed from the outset in the terms that will enable it to be resolved. The newness of the problem prevents it from being apprehended clearly, resulting in its imprecise and obscure formulation. In the end, 'the clarity of the hypotheses is connected to their success. It can never be assumed that the articulation of a problem is clear and thus simple as long as this problem is not resolved.'[37] There thus exists a problem that pre-exists the research – in

35 Ibid., 128.

36 Georges Canguilhem, 'L'Histoire des sciences dans l'oeuvre épistémologique de Gaston Bachelard', 174.

37 Gaston Bachelard, *Étude sur l'évolution*, 88.

Bachelard's case, how heat spreads in solid bodies – but this problem is not contained solely in the general articulation of the question. A problem has a specific *form*, and is constantly being reformulated as the research advances and a solution is approached. In the end, a problem cannot find its clear and precise formulation until it is resolved. There is not in the first instance a problem, posed in its entirety from the outset, and then a fumbling towards the solution that will become the object of the unique moment of invention through genius. There is, rather, a collective research process involving partial solutions and re-elaborations of the problem, constant changes and about-faces. Each partial solution has a degree of autonomy: it is conceived within a certain framework, it has a degree of effectiveness, it resolves a singular problem and makes possible new results, and it is part of a specific and potentially productive system. But these solutions also contribute to the collective process of resolving the more general problem.

This theory of a problem and its evolution is, I believe, crucial for all of French historical epistemology and constitutes an important mark of how Simondon's work pertains to this approach. Canguilhem, who published *La Formation du concept de réflexe aux XVII^e^ et XVIII^e^ siècles* in 1955, remarked that the first chapter of Bachelard's volume was entitled 'La formation des concepts scientifiques au XVIII^e^ siècle'.[38] François Albera and Maria Tortajada note that Michel Foucault was still a part of this tradition in 1978 because 'what these thinkers share is the ambition to write the history of the "formation of concepts"'[39] – a defining expression borrowed here by Foucault (via Canguilhem?) from Bachelard.

The notion *problem* was already absolutely central to the work of Georges Canguilhem. It is not by chance that his thesis in medicine was entitled *Essai sur quelques problèmes concernant le normal et le pathologique*. 'The problem' appears in the first lines, and the introduction was entirely structured by the concept before concluding with a programme: 'By proceeding in this way, I believe I am acting in conformance with a demand of philosophical thinking, which is to open problems up rather than to close them'.[40]

Canguilhem repeats his core task several times: not to *close* problems, but to work at 'their precise position and at clarifying them.'[41] A problem

38 Georges Canguilhem, 'L'Histoire des sciences', 174.

39 François Albera and Maria Tortajada, 'The Dispositive Does Not Exist!', 39.

40 Georges Canguilhem, *Le Normal et le pathologique*, 9.

41 Ibid., 8.

does not exist without form; it must be *posed*, and its position is the central point of the epistemological and (thus) historical approach. In this sense, his thesis is profoundly and precisely Bachelard-like in nature. Canguilhem concluded his introduction to the 1966 reprinting of the thesis in the following manner: 'By adding a few new considerations to my initial *Essai*, I am hoping only to document my efforts, if not my success, at preserving a problem which I believe to be fundamental in the same state of freshness as these ever-changing factual data'.[42]

Twenty-three years after writing his thesis, he was still committed to a permanent reopening of the problem, in a gesture that is only seemingly modest because, from a Bachelardian perspective, the clear position of the problem involves not only its resolution, but also an understanding of its solution. To work at the position of the problem is thus to have both the solution and the opening: 'the important thing is not so much to bring a tentative solution than to show that a problem merits being posed.'[43]

Simondon's theory of the genesis of technical objects would adopt a model similar, all things being equal, to that invented by Bachelard. In Simondon, the evolution of technical objects is fundamentally a process of concretization, and 'concretization can be translated into an element of simplification.'[44] In fact, the *abstract* phase of the technical object corresponds to the early stage of positioning the problem, in which the problem, or the machine, are not yet understood according to their own coherence but appear initially as a possible new arrangement of existing elements – as interconnected concepts already constructed in other contexts, a montage of already elaborated *dispositifs* seemingly able to combine their efforts, because they present certain *analogies*. At that point the technical object tends to become concrete, meaning to transform itself (to be transformed) by reflection onto what is the basis of its cohesion, onto its internal logic, the circulation of information, and the energy that characterizes it, and its form, and self-correlation. Its history, like that of the problem, plays out in a history worked by a dialectic of the simple and the complex; as Simondon remarks:

> These causes [of the evolution of technical objects] essentially reside in the imperfection of the abstract technical object. Because of its analytic aspect, this object uses more material and requires more construction

42 Ibid., [5].

43 Ibid., 116.

44 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, 38.

> work; it is logically simpler, yet technically more complicated, because it is made up of a convergence of several complete systems. It is more fragile than the concrete technical object, because the relative isolation of each system that constitutes a functioning sub-system threatens, in case of its malfunction, the preservation of other systems.[45]

In this way, the evolution of problems and the evolution of technical objects obey certain shared laws,[46] in particular a general principle of simplification and clarification: put schematically, after an initial, confused stage, in which the issues and the ranking of data are not grasped, there follows another phase, in which the real internal logic of the problem to be resolved is understood. This phase is, in fact, contemporaneous with the resolution of the problem itself.

The question is thus not whether Ducos du Hauron 'foresaw' cinema, but rather to understand what his own problem was and to what extent he contributed to the formulation and possible partial resolution of this general problem, which we could call 'cinema'. This involves circumscribing the problem, but does not mean that Ducos du Hauron's formulation of this problem would be exactly the same as that of Edison or Lumière – or of Charles Pathé or Edwin S. Porter. And this does not mean that Ducos already had an 'idea of cinema', to paraphrase the title of François Brunet's volume. For what interests Brunet is something quite different: he seeks to understand at precisely which moment this *idea* of photography took shape, the idea that became the culturally dominant definition of the medium by orienting its cultural reception, its theoretical conception, and its technical practices and evolution in the nineteenth century.[47] But this idea may be quite different from the real, concrete problems of the inventors of photography, from the task they set themselves, from what they actually achieved and the way they understood this, and, finally, from what we can reconstruct as their epistemological suppositions.

45 Ibid., 30.

46 This is a parallel that, to the best of my knowledge, has never been noted, even though commentators have remarked Simondon's debt to Bachelard. (See, on another topic, the idea of an 'epistemological perspective inherited from Bachelard' in Simondon's work, as described by Vincent Bontems, 'Quelques éléments pour une épistémologie des relations d'échelle chez Gilbert Simondon'.

47 This idea could deepen into a 'paradigm', as François Albera describes for the cinema in 'Le Paradigme cinématographique'.

A Louis Ducos du Hauron Patent (1864)

Few texts have received as much praise from (French) 'pre-cinema' historians as the patent application of Louis Ducos du Hauron on 1 March 1864 for 'a device intended to reproduce photographically any scene, with all the transformations it has undergone for a defined period of time.'[48] Sadoul's admiration for it was taken up in the volume *Cinéma d'aujourd'hui*, edited by Jean Mitry in the fall of 1976, in an article by François Ramasse,[49] one of the longest articles devoted to what Mitry calls the 'avant-garde' of 'precursors' (Duboscq, Dumont, Cook and Bonelli, Ducos, Coleman Sellers, Henry Heyl and, curiously enough, Jules Janssen). Finally, in *The Great Art of Light and Shadow* (originally appearing in French in 1995), Laurent Mannoni would devote five pages of praise to the person who was 'certainly the most original and inventive' of 'those who aimed to capture life by photography' in the 1850s and 60s.[50] Firstly, each of these authors has directed their praise at the 'Applications' section of this first patent application by the young Ducos du Hauron, aged 26 at the time and who would later distinguish himself, as is well known, in colour photography and stereoscopy using the 'anaglyph' system, which cleverly joined colour and relief.[51] This section, quoted at length in every commentary on the patent, is notable for the similarities between its list of topics and what would later become the subjects of the earliest film strips:

> Through my device I lay claim, in particular, to being able to reproduce a procession, a military review or military manoeuvres, the back and forth of a battle, a public celebration, a theatre stage, the movements and dances of one or more persons, a persons changing facial expressions and, if one like, the grimaces of a human head, etc.; a maritime scene, the movement of the waves (tidal bore), the fast movements of clouds across a stormy sky, especially in mountainous regions, the eruption of a volcano, etc., etc.; the picture which unfolds before the eyes of an observer circulating in a town, in a monument or in an interesting land.[52]

Beyond these resemblances with the topics of the future moving pictures by Lumière or the film strips of Marey, Demenÿ, Wordsworth Donisthorpe,

48 Louis Ducos du Hauron, French patent no. 61,976, 1 March 1864.
49 François Ramasse, 'Ducos du Hauron'.
50 Laurent Mannoni, *The Great Art of Light and Shadow: Archaeology of the Cinema* (1995).
51 On the work of Ducos, see Jacques Foiret, 'Louis Ducos du Hauron'.
52 Ducos du Hauron, French patent no. 61,976, pp. 14-15.

etc. – resemblances that, at this early date, demonstrate the existence of an already culturally constituted iconography of movement – this long list, which must be extended to repletion beyond the 'etceteras' that punctuate it, leaves the impression of a profound strangeness. This strangeness is due not to the subjects, which, on the contrary, are familiar, but rather to the very length of the enumeration. This goal is to exhaust the forms of movement and present the full range of what the world offers the device for recording. Naturally, there is an internal logic to the patent application, which requires that one vaunt the invention by demonstrating the importance of its contribution. But there is also visible a theme that would return in the reception of the earliest Cinématographe projections: this device is able to reproduce *every* movement and *every* transformation – the simple and the complex, the successive and the simultaneous, the slight and the massive, the geometrical and the chaotic, the unique and the infinitely multiple. The strangeness lies in the gap between the obviousness this property of the device has for us today, in the 'cinema paradigm' in which we are steeped, and the fact that this obviousness, precisely, was apparently not yet common.

Before describing its applications, Ducos detailed his machine's principles and operation. The opening paragraphs, for those of us reading him *after* the solution to the problem, already join the familiar and the intriguing: 'My procedure consists in replacing, rapidly and without confusion, before the eyes not only of a single individual but also, if one wishes, those of an entire assembly, enlarged images of a great number of instantaneous prints obtained successively at very close intervals'.[53]

One cannot read these lines without a degree of astonishment, forcing us to 'place our minds before the problem as it presented itself to observation originally,' as Bachelard wrote. Specifically, one can only be astonished that Ducos speaks here of 'instantaneous prints'[54] in 1864, as if this were commonplace at least fifteen years before the large-scale dissemination of 'instantaneous' photography procedures. Equally astonishing is the use of the expression 'enlarged' and not 'projected' images (these are not the same thing conceptually and perhaps also concretely). Likewise, the fact that this programme for showing 'moving' images (this term is not used here) to 'an entire assembly' was a part of this project in 1864,[55] as if it were

53 Ibid., 2.

54 Today, the word 'instantané' is used in French to denote what in English is called a snapshot – Translator's note.

55 Laurent Mannoni writes: 'Ducos du Hauron also wanted to project his series of positive images, to pass on his pleasure to everyone, knowing the illusion would not be complete without the traditional magic lantern'. (*The Great Art of Light and Shadow*, p. 257). The nature of this

obvious that the series 'photographic reproduction of any scene' should belong for cultural reasons to the series light shows rather than to that of the traditional ways in which photographs were viewed – paper and back-lit plates were preferred over projection. Naturally, cinema's projected form was never complete in concrete terms, the Lumière Kinora being a perfect example. Nevertheless, culturally it was seen as preponderant throughout the twentieth century, and thus already before then. We can only continue to be astonished. But the most surprising thing is undoubtedly Ducos's description of his project:

> It is primarily based on this observation, that it is not necessary for us to be in a state of complete immobility to see an animated scene well, and that a gradual shift or regular oscillation of our body in no way interferes with our vision, especially in the case of objects which are not too near.[56]

From the outset, in this initial 'observation', the viewer's body irrupts – it is not the body struck motionless or immobilized, not at all the body of the French 'film apparatus' theorists of the 1970s (Jean-Louis Baudry, etc.). On the contrary, the procedure embodies the view of the 'animated scene' in a body that itself is moving, either 'gradually shifting' or 'regularly oscillating.'[57] The explanation for this new sensuality granted to viewing, for this connection between the eye and the body, which is rather unusual in Western optical culture, is not immediately apparent in the patent application. But the preliminary position of this 'observation' demonstrates its importance: it is upon this that the entire *dispositif* is 'based'. It is thus impossible to overestimate its importance.

In fact, the patent application describes four principal machines that could be produced with variations: home-use model, stereoscopic model, etc. There was a 'simple device of limited duration' made up of 'two parts: 1, a simple device for making prints; and 2, a simple device for showing them',[58] and a 'dual device of indefinite duration',[59] also made up of two similar parts.

'premonition' is what must be interrogated epistemologically. The almost unconscious or unformulated quality Mannoni suggests reveals the degree of prejudice in this paradigm, which needs reconstructing.

56 Ducos du Hauron, French patent no. 61,976, p. 2.

57 Note that here there reappears the topology of the near and the far seen in the work of Charles Wheatstone.

58 Ducos du Hauron, French patent no. 61,976, p. 3.

59 Ibid., 9.

How can we attempt to reconstruct the principles that guided Ducos, his problems and specificities? The task is neither to identify the extent to which Ducos 'foresaw' the cinema, nor to present him as a 'precursor', but rather to be attentive to what may tell us something about the complexity of a problem no longer available to us. It is precisely in what does not 'match' the cinema (as it would take form) that there resides what can inform us about the epistemological conditions of its emergence. We must recover what was difficult and complex; we must recover the perplexity of what Bachelard termed the 'original observation'. Every commentator on Ducos named above has emphasized the fact that his machine, in its 'simplest' configuration in the patent application, was equipped with 290 lenses. This, of course, appears to be a crazy idea – now that we 'know' that the solution 'required' the use of devices with a single lens. We need to put ourselves in the position of understanding how, at a certain moment (under certain technical, cultural and epistemological conditions), this manifestly complex option may have seemed to Ducos the *right solution to a certain problem*.

Firstly, however, we must make clear what the technical conditions of this project were. For Ducos, photography was carried out on glass plates, and possibly on paper, using the collodion procedure. Silver gelatin bromide procedures, which made possible 'instantaneous' photography in the sense that would later become dominant, that of the 'snapshot', would only appear in the late 1870s and photographic celluloid was not marketed by Eastman until the very late 1880s.

Ducos thus used 'collodionized sheets of glass,'[60] like his contemporaries. Technically, his problem would be that of making 'successively at very close intervals' on one or more plates 'a great number of instantaneous prints.' How to achieve this?

An initial option would have been, as Henry Du Mont chose for his patent application of 1861 (Illus. 20), to place the plates in series. Each plate would hold a photograph, and the device, using some sort of mechanism – Du Mont proposed three – would pass the plates before the lens in succession. The device could thus have a single lens and seem relatively 'simple' – closer to future moving picture cameras than Ducos's device.[61] Its mechanical problems were considerable: the plates were heavy and fragile; their inertia shook the device, which could only hold a dozen plates, etc.

60 Ibid., 5.

61 Henry Du Mont, British patent nos 1457 and 1861. See Laurent Mannoni, *The Great Art of Light and Shadow*, 252-255. 'It was all very primitive and jerky, but Du Mont was on the right track', Mannoni writes (p. 254).

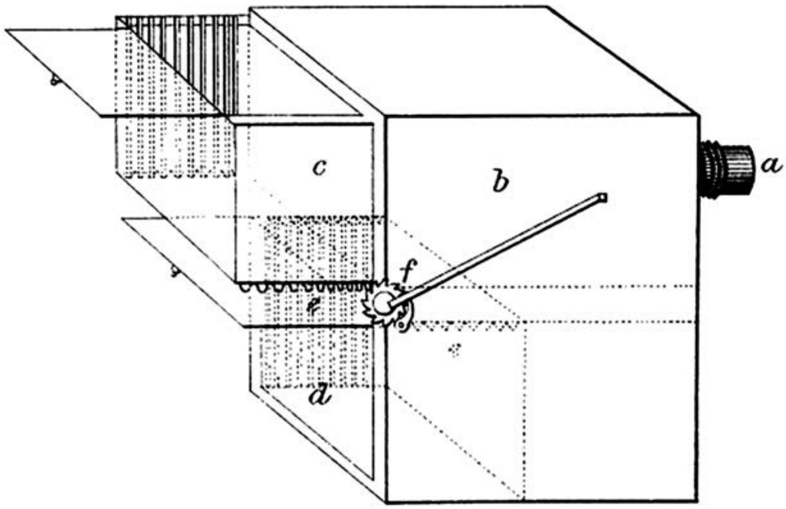


Illustration 20 – Henry Du Mont, machine for obtaining series of negatives on glass plates. Turning the crank moves the plates behind the lens. When imprinted, each plate drops into the lower drawer. English patent 1457, 8 June 1861.

Whether Ducos was aware of Du Mont's *dispositif* or not, he took another path. In his system, a plate did not bear an 'elementary image' (as Louis Lumière would describe it), but rather the whole series. This altered all the problems.

It is possible that Ducos initially had Du Mont's idea and gave it up. It is also possible that Ducos did not envision this option. For the solution he proposed was completely consistent with his conception of the effect that would be produced by the machine: 'One will think one is seeing a single immobile image, in which all the gradual changes in the form and position of objects will take place as in nature'.[62]

Thus, the entire series forms only a single image: the fundamental unit is no longer the 'elementary image' but the whole scene, reproduced with all its transformations. The oneness of the plate on which the image is borne was physical, but also logical and conceptual. This cohesion of the series would endure with Lumière and was tied to the oneness of the physical base: there, a strip of film (seventeen metres long) was equal to a picture (of 50 seconds in length). Nothing was cut, nothing was edited, nothing was interrupted: it was a single block.

Moreover, Ducos formulated a seeming paradox: by becoming animated, the series of images would become 'a single *immobile* image' (my emphasis).

62 Ducos du Hauron, French patent no. 61,976, p. 17.

The vocabulary of movement has completely disappeared: everything was now only immobility and change. An enormous quantity of movement is needed to achieve this, which contains movement but also something else: immobility and transformations. This is the basis of *animation*.

While this stance inherently resolves certain problems – for example, that of *intermittence* (i.e. the assumed necessity for the intermittent capture of movement), which, consequently, (practically) ceases to be an issue – it creates others. One must succeed in creating a great number of images with close intervals between them on a plate. The plate will thus be large in order to accommodate all these images. It will remain immobile. To produce the series, it would be necessary to have as many lenses as images. The patent application itself gives no precise quantitative information – neither the dimension or number of lenses, nor the speed, exposure time, or length of the scene being reproduced. This reinforced the general nature of the patent application, but also the reader's impression of an abstract description. It was the illustrations at the end of the statement that supplied more concrete indications of what Ducos had in mind. The first two illustrations (Illus. 21), show a 'dark room'[63] equipped with ten rows of fourteen lenses, each alternating with ten rows of fifteen lenses, for a total of 290 lenses of 'small dimensions and equal focal length [...] alternating regularly, in the sense that any lens on any level is situated on a vertical line which passes through the middle of the interval between two lenses on the next level up or down.'[64] Here, the notion of *interval* comes into play; regularity was important not because it made the duration of the images or the time between them equal – Ducos never posed this question – but for geometrical reasons: given the complexity of the whole and the number and small size of the components, only a very finely-calibrated and regulated division of the images would make the device possible.

The division of the lenses into staggered rows was determined by the major technical problem confronting Ducos: that of organizing the taking of the images and placing them in succession. Once imprinted on the 'collodionized sheet of glass,' every image is contemporaneous: the machine must geometrically inscribe their order of succession in a coherent fashion. Alongside this was the fact that in the collodion photography technical system, intermittent exposure to the light was not necessarily regulated by

63 Ibid., 5.
64 Ibid., 3.

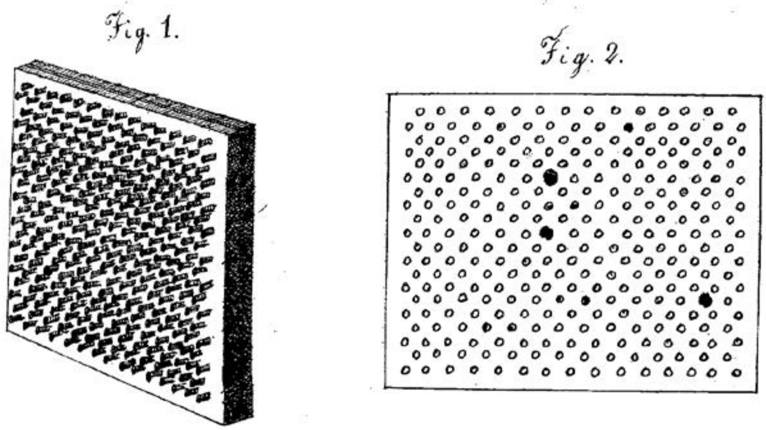


Illustration 21 – Louis Ducos du Hauron. Dark room with 290 lenses, arranged in staggered rows.

an autonomous mechanical *dispositif*. Frequently, this was achieved with a 'plug', i.e. manually removing and replacing the lens cap. A mechanized shutter would make no sense, given the relatively long exposure times, on the one hand, and the non-standardized development procedures, on the other. Ducos thus had to find a way to organize the successive and regulated opening of his great number of lenses without a technical shutter tradition at his disposal.

The solution he proposed was quite fine, even though its mechanical realization was rather complex. He would scan the plate with light, the images being impressed line by line from left to right and then from right to left. Naturally, it is difficult here not to think of the scanning of the cathode screen by the photon in television, as if the series of photograms conformed to this principle of describing the base through scanning – a series of inversions taking place from one *dispositif* to the other between elementary image and animated/temporalized image.

To carry out this scanning, Ducos positioned two opaque bands, 'either of black paper or black fabric,'[65] the width of the inner frame of the dark room, passing vertically at harmonized speeds (Illus. 22). One band had as many holes as there were lenses, arranged in diagonals (Illus. 23) and constituting the temporal track of the succession. In fact, the appearance of this ribbon is quite similar to that of mechanical pianos and organs, which

65 Ibid., 4.

are also responsible for the precise temporal division of the sounds these instruments produce. The other ribbon had a slot as wide as the collodionized sheet of glass and was as tall as two rows of lenses. It ensured that the holes in the first ribbon did not cover the desired lens, or those of the other levels of the series. The first ribbon was pulled along at a constant, uniform rate 'using a motor of some kind,'[66] while the second tape was taken down by a crank each time a level was entirely uncovered. The second tape was thus necessarily intermittent, but its movement was slower than that of the impressions: one had to drop down one row every fourteen or fifteen images, and the movement had the same duration. In concrete terms this meant, moreover, that this second tape could also descend continuously and automatically, even though Ducos did not envision this, as he stuck with the idea of manual operation decided by the operator. The operator thus had to observe the tapes attentively as they unspooled throughout the taking of the image.

The *dispositif* thus organized a fixed number of heavy elements – a wooden darkroom, a glass plate, a great number of lenses, feeding and take-up cylinders for the two opaque ribbons, a motor, and a crank mechanism – to work with two synchronized moving elements, one continuous and one intermittent: the perforated cloth ribbons. Ducos's machine adopted a fixed base that was unorthodox with respect to the history of 'pre-cinema' – the 'collodionized sheet of glass' – but used it in tandem with what traditional historiography considers the 'right' base: a strip, and even a perforated strip. Nevertheless, we see here a series of shifts or scissions with respect to later solutions. These would be based on a clear distinction between hardware and software: on the one hand, a machine with a synchronized mechanical shutter and intermittent advancement. On the other hand, the moving image base would physically inscribe the temporal succession by means of its form as a strip adapted to advance, and later by means of a system of perforations. With Ducos, these distinctions are more complex and carried out on another basis. Neither the software – the images' base, the glass plate – nor the machine record the temporal succession: they only realize the multiplication of the images on the base, not their temporality. Temporality is inscribed by the most complex element, the doubly exterior element – exterior to the base and also literally exterior to the machine – the *dispositif*'s only moving element, which regulates every temporality factor, meaning both the blockage of the light – the exposure time – and the organization of the succession of the elementary images. This element

66 Ibid., 6.

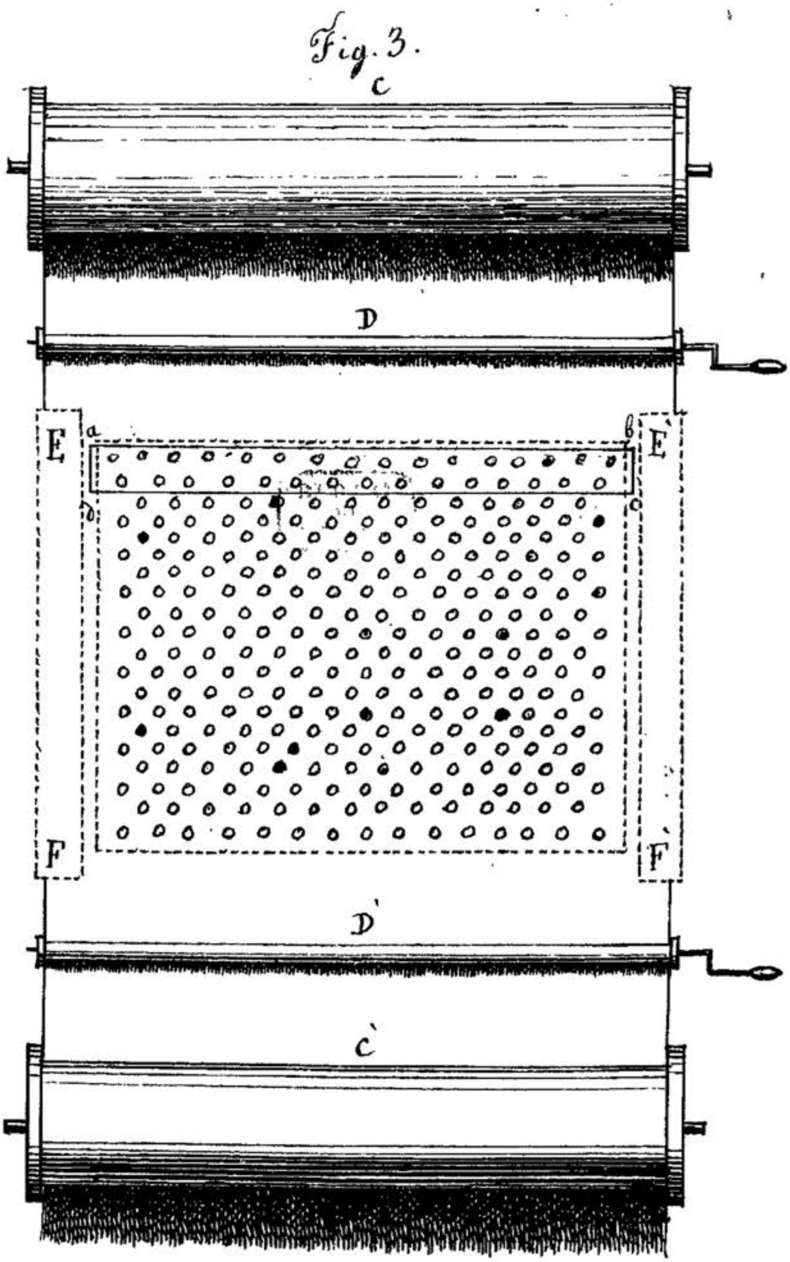


Illustration 22 – The room equipped with two fabric bands pulled along by a motor (C-C') and crank (D-D'). French patent 61976, 1 March 1864.

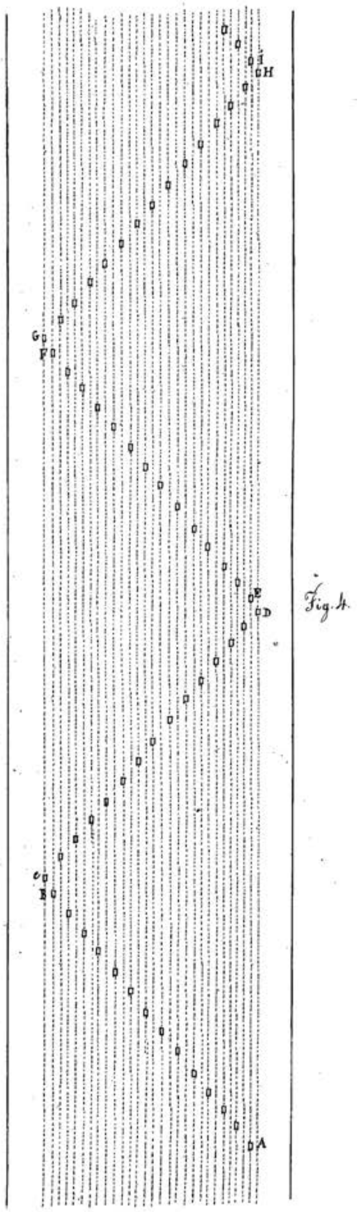


Illustration 23 – The fabric band perforated with holes in a diagonal pattern, one per lens. French patent 61976, 1 March 1864.

adopted the 'cinematic' form of the perforated strip, if I may be permitted the expression, as this notion is anachronistic and, moreover, is in the form used by barrel organs.

It is interesting to note that, in fact, the length of this strip determined the duration of the scene reproduced, more so than the number of lenses or the size of the sheet of glass. Indeed, the 'dual device of indefinite duration' later described by Ducos made it possible to go beyond the limited capacity of the glass plate by doubling the *dispositif* through the use of two juxtaposed symmetrical machines, and by substituting one of the two plates while the other was being impressed (Illus. 24). This meant the *dispositif* would have 580 lenses, but also, in particular, that it would require three operations when used.[67] But even in settling the question of the duration of the base in this way, Ducos had to admit that, in the case of the perforated strip, the problem was a little more complex:

> Because the length of the strip was necessarily limited, if one wanted to reproduce a scene of considerable duration one could run the strip backwards. Given the combinations indicated above [...] the strip would function just as well going up as going down. Except that at the precise moment when one starts it going backwards, the substitution of one sheet of glass for the other in the darkroom must be handled very quickly.[68]

The length of the perforated strip was the largest factor determining the possible duration of the scene, and it was only with conditional measures that Ducos saw a way around this constraint. Compared to a traditional photographic darkroom, what was different about Ducos's machine was not so much its impressive number of lenses as the addition of this mechanized moving strip to the photographic equipment. The difficulty – the abstract nature of the machine, in Simondon's terms – arises from the fact that this strip could only be operated from outside the device and that its operational correlations with the other elements were not established.

Once the sheet of glass was impressed, the issue arose of seeing and showing the moving images, or rather this immobile and changing image.

The patent application describes this operation as taking place in two stages. Before his description of this 'simple device for showing prints,'[69]

67 At least 580 lenses, as the mechanical operations were distinctly complicated by those required by the wet collodion procedure, which in large part had to be carried out at the same moment as the impression: 'Generally speaking [...] the operators should be fairly numerous so that there is no delay or interruption; as the sensitizing is carried out simultaneously on the various sheets of glass in different baths, there will always be another ready to receive the action of the light. This same remark also applies to the other operations: applying the collodion to the glass, developing, fixing and intensification'. Ibid., 12-13.

68 Ibid., 12.

69 Ibid., 7.

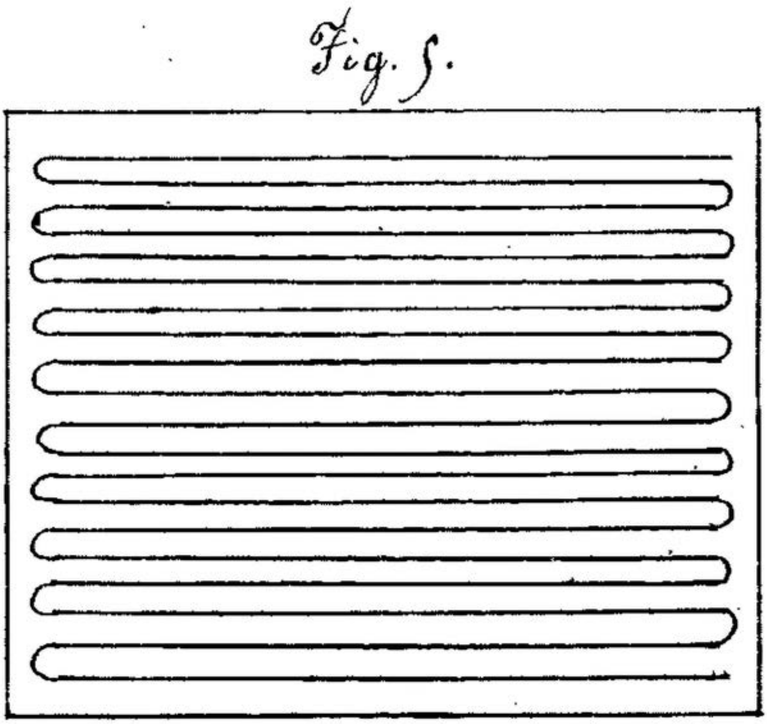


Illustration 24 – The 'dual device of indefinite duration'. French patent 61976, 1 March 1864.

Ducos introduced the intermediary phase, that of observing the plate itself:

> There will thus be obtained, on the same sheet of glass, a picture made up of as many small instantaneous prints as the darkroom has lenses, and these prints, examined one by one, will show all the successive transformations which took place in the scene depicted, from the moment the light entered the first lens to the moment it entered the last one.[70]

The 'picture'[71] was thus the entire sheet of glass, the series. Therein lay the fundamental unity that could be broken down into 'small instantaneous prints,' which are not seen as images in the full sense of the term, even when

70 Ibid., 6.

71 The singular returns a few lines further on (still on p. 6): 'Using this picture [*cliché*], one will obtain a *transparent positive on glass*'. Emphasis in the original. (In current usage, a *cliché*

examining the plate itself instead of the moving image of the reproduced scene. This analytical phase of examining the elementary prints 'one by one' seems here to be a strange and remarkable moment, an additional benefit of the machine, not crucial yet interesting, and not calling into question any of its conceptual bases.

Seeing the image is thus, firstly, to look at the base. Next comes the second device, that which is 'designed to show the prints.' A certain photographic state is still apparent here: the positive taken from the negative picture is a contact print. It is a glass positive the same size as the negative. The second machine will have the same basic structure as the first: 'a darkroom, the same size as the previous one [...] and the camera lenses will be replaced by an equal number of optical lenses.'[72] But here arises an 'essential difference,'[73] which renders any strict reversibility impossible: 'The optical lenses will be susceptible of moving in every direction so that, through their relative directions, the enlarged images of the prints, placed before each of them, can be superimposed on a vast canvas'.[74]

In fact, it was necessary to converge these 290 (or 580) lenses in such a way that the images would be precisely superimposed on screen. This operation – 'an easy matter of trial and error' (!), Ducos writes[75] – could only be carried out manually, lens by lens, taking any one of them as the fundamental reference. It is hard to see such a task as being easy, supposing it were possible, if one takes into account the number of camera lenses, but also their small size, the level of precision required to enlarge the images on a 'vast canvas', etc. For Ducos, this difference was 'essential'. The ability to orient the camera lenses did not seem to him to be transferable to the device for making prints: that device should have fixed lenses on parallel axes.

The other difference was no less major: the perforated strips were no longer necessary to show the prints. The scanning was no longer regulated by the machine, but rather carried out manually by the operator: 'a bright light is shown on each print successively by moving them along at a certain speed in the order in which they were made.'[76]

is a snapshot, a sense which was introduced in French with the first 'instantaneous' rolled-film cameras – Translator's note.).

72 Ibid., 7.

73 Ibid.

74 Ibid.

75 Ibid.

76 Ibid.

No mechanization of this movement was proposed. Ducos envisioned neither a wide light source (of uniform intensity across the surface of the glass), nor a great number of disparate sources, organized by the primitive bands, but rather a single mobile source of spot lighting. The manual nature of the movement shows above all that the inventor did not believe that any precision was necessary here.

In any event, the possibility of carrying out this movement imposed the alternation of the direction of the lines of images (towards the left and then towards the right, etc.), corresponding to the minimal trajectory for the operator: at the end of the line, he need only lower the bottom optical lens in order to start off in the other direction (Illus. 25).

One of the most remarkable aspects of this machine – which, as we have seen, has many such aspects – is that Ducos did not necessarily envision a black moment between the projection of two successive prints 'if the lit part of the glass is large enough, in its successive displacements there will be no interval between the moment when a single object ceases to be lit on one print and when it begins to be lit on the following print.'[77] For Ducos, therefore, there was neither any intermittence in the displacement of the sheet of glass, nor an interval between the successive images. None of the fundamental concepts we have learned to see as essential to the machine 'cinema' plays a role here. What made it possible for Ducos to picture the absence of intervals is the fact that he was not thinking in terms of a complete elementary print, but considered separately each object of the scene to be reproduced. The objects in the image n+1 are already beginning to be lit when those of image n are still slightly lit. The disappearance of any interval is thus authorized by the continuity and lack of intermittence in the displacement of the light source. Ducos conceded that there might be a small temporal gap but thought this to be without importance: 'Even supposing there is a slight temporal interval during which an object is not lit, the persistence of the impression of light on the eye will fill this gap'.[78]

Here is where we see the idea of 'persistence of vision' for the first time in Ducos's statement, but the text never mentions the Phenakisticope, Plateau's work, etc. In addition, the role attributed to this 'persistence' is not that of reconstituting the illusion of movement, but rather only absorbing any possible black interval between the prints in projection and filling in a gap which was in any event minimal.

If the movement is carried out correctly by the operator, then

77 Ibid., 8.
78 Ibid.

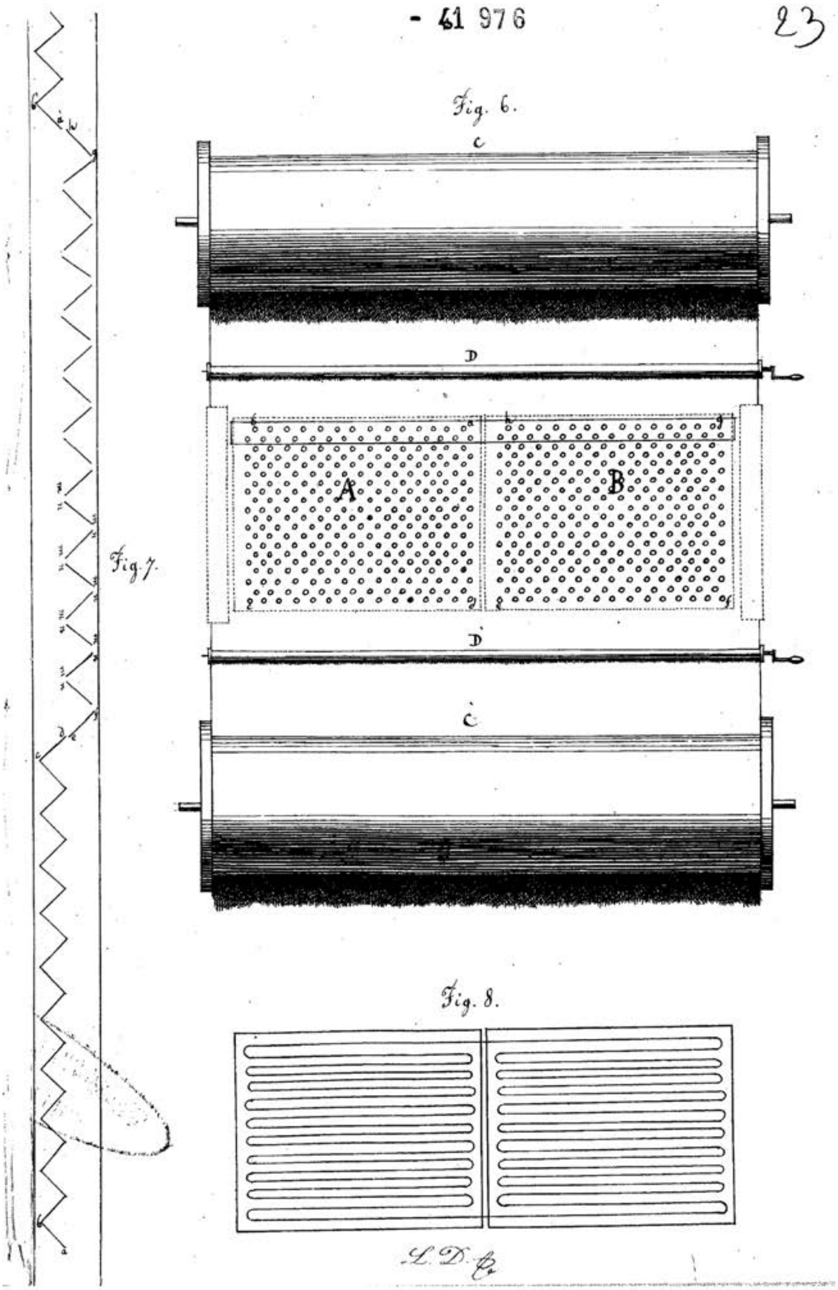


Illustration 25 – The images moving across the plate. French patent 61976, 1 March 1864.

> It will be in a sense a living depiction of nature, and if the speed of the light source is the same with which the openings in front of the lenses succeeded one another at the time taking the negatives, the same scene will be reproduced on the canvas with the same degree of animation.[79]

Taking the pictures and their projection – to employ today's terms – at the same speed was thus a non-obligatory and non-systematic special case. The effect would be produced in any event, as any variation would affect only the 'degree of animation.'

Ducos then discussed what appears to be a defect in the machine, however minor, and retrospectively explains his opening paragraphs:

> Except that the effect will only rigorously be the same if the prints are taken successively from the same point of view; the real effect will be that which is produced in the eyes of the viewer, if this viewer had observed the natural scene while swaying slightly the width of a row of lenses. But this swaying motion, as one can see for oneself, is of no importance and in no way interferes with the viewing; it cannot become detrimental and at most could lead to confusion only in the case of very near objects.[80]

This is what the procedure 'primarily rests' on: the gradual variation in point of view, which Ducos interprets as a 'swaying' of the viewer's body. This swaying was imposed on the viewer throughout the viewing by the structure of the machine itself. This, of course, is a form of constraint, but the essential point for Ducos, which he emphasizes here, is that the movements of the viewer's body do not interfere with their vision. This movement does not disturb their vision and must be distinguished from the movement of the 'device used to obtain the prints': this movement must be absolutely proscribed if one is to avoid out of focus images and confusion between the images. Ducos insists repeatedly in the text on the radical requirement 'that no jolt or movement make contact with the darkroom,'[81] because the mechanisms would record this 'shudder.' For Ducos, passing from one lens to another is movement, but it is not the same kind of movement as that of the device; it only reproduces the oscillations of the viewer's body and these

79 Ibid.

80 Ibid. Here, we find the 'little difference' and the topology of the near and the far which had become familiar since Wheatstone.

81 Ibid., 3.

oscillations do not produce images out of focus. They are thus admitted and do not spoil the images. For Ducos, then, and we must emphasize the fact, there is no strict analogy possible between the device used to obtain the prints and the human eye. An ambiguity remains, however: the embodiment of the gaze found in Ducos's project is carried out by reaffirming the lack of interference between body and vision, in that the body and its movements are, in fact, of 'no importance' to the eye.

Ducos devised 'supplementary' viewing combinations and on 3 December of that same year, 1864, he filed a request to add to his patent application, in which a series of 'improvements', giving rise to a new set of issues, was based on the observation of 'drawbacks which had to be remedied.'[82]

The question of whether or not Ducos actually brought these machines into existence has been raised by every commentator. Sadoul thought it was almost certain that they never saw the light of day:

> 'Mr. Ducos du Hauron sent to the Musée centennal the plan for a cinematic system going back a good number of years now, but which was not executed'. This sentence from the report of the 1900 World's Fair, written by Marey, documented or in any event approved by Ducos, who was still living at the time, appears to me to prove that his device, no matter what one says about it, was never built.[83]

The extreme complexity of the conception and handling of these *dispositifs* leads one to think that that they were indeed never put into service, even though the young man could assert in his patent application that 'the positive and the device designed to contain it can multiply indefinitely and spread across the entire world.'[84] Already, 'technical reproducibility' could guarantee the machine's success!

Whatever the case, the machine having been constructed or not has little bearing on the present discussion. Whether he was able to put his project into service or not, Ducos's ideas were nonetheless part of a precise technical and epistemological system, whose consistency those ideas can help us recover. The very complexity of the system makes clear what could be the initial phase of the technical object's abstraction Simondon speaks of, and shows how this abstraction is tied to the original state of a problem whose

82 Ibid., 27. This addition is commented on by Laurent Mannoni in *The Great Art of Light and Shadow*, 258-261.

83 Georges Sadoul, *Histoire générale du cinéma*, vol. 1, 37 (footnote).

84 Ducos du Hauron, French patent no. 61,976, p. 6.

issues, forms, connections, and arrangements are not clearly perceived. Ducos du Hauron's project may well have been close to the project of Edison, Lumière, or someone else. But the way he posed the problem, the way he saw problems, was completely different, not only because the technical system in which he operated was different (wet collodion glass plate photography, the lack of a mechanical shutter, etc.), but also because the concepts he employed for conceiving his machine were not the same. The concepts interval, animation, movement, transformation, and intermittence did not have the same meaning or explanation. Ducos's technical problems consisted in knowing where, in photography's technical system, to place movement in order to incorporate it in the image. By making a perforated strip move, by making a single source of light move, but not the darkroom or the base? Perhaps by making the viewer's body move? The movement must be somewhere in the machine, to speak like Henri Bergson, but where? What we can see from a technological and epistemological study of Louis Ducos du Hauron's project and his problems in March 1864 is the profound initial complexity of this arrangement.

Charles Cros and 'Scenes in Motion' (1867)

Today, the coherence of the protean and rather odd life work of the poet and inventor Charles Cros is difficult to apprehend. Firstly, Cros is undoubtedly best known for and owes his reputation to his poetry; he is the author of the sumptuous volume *Le Coffret de santal*, co-published in 1873 by Alphonse Lemerre in Paris and J. Gay in Nice. A founder of the 'Zutiques' literary group, he read his poems and monologues in cabarets such as the *Chat Noir*, and gave lectures to paying audiences in Paris.[85] His poem 'Hareng Saur' was made famous by a version set to music by Cabaner and sung by Coquelin Cadet in the 1880s.

Cros was also an inventor, versed in the sciences and their imaginative applications. He was involved in one of the most extraordinary coincidences in the history of science: the simultaneous and independent presentation on 7 May 1869 of two theses proposing 'a solution to the problem of colour photography' to the Académie des sciences. The first was written by Charles

85 On 9 July 1873, Cros gave a lecture at the Salle des conférences at 39 boulevard des Capucines entitled 'Qui sommes-nous? Où allons-nous? À qui le monde? L'Asie, l'Europe occidentale, l'Amérique, l'Isthme de Panama, la Chine, les races qui suivent le soleil'. Two days later, he presented *Le Coffret de santal* in the same venue. See Charles Cros, *Inédits et documents*, 263.

Cros, the second by Louis Ducos du Hauron, five years after his patent application of 1864. This triggered a dispute between Cros and Ducos as to whose colour photography invention came first, something that did not prevent the two men from becoming friends.[86]

Here, I would like to replay this dispute from a different angle, one which, nevertheless, is not completely independent of the question around colour photography. For before these scientific and poetic publications, performances, and projects, on 2 December 1867, Charles Cros deposited a sealed letter with the Académie des sciences, which was a method for protecting an idea. It contained a text written on 28 November of that year entitled 'Procédé d'enregistrement et de reproduction des couleurs, des formes et des mouvements'. At Cros's request, the letter was not opened until 26 June 1876, on the occasion of the Académie being sent two colour photographs. At that time, the journal *Comptes rendus hebdomadaires des séances de l'Académie des sciences* published a few paragraphs from the text – only those describing the technical principles of colour photography, with respect to the earlier quarrel between Cros and Ducos.[87] In his letter, Cros showed that the principles that would lead to the concrete realization of the project, proven by the two enclosed prints, had already been formulated by him two years earlier. The question of movement mentioned in the title clearly did not interest the Académie, which did not reproduce this section, even though it contained an idea never before seen in 1876. The French scientific institution's indifference appears to demonstrate that this question had a more modest place at the time than we might believe with hindsight – more modest than what is usually acknowledged by the historiography of 'pre-cinema', a historiography that, for the most part, constructed the epistemological role of 'movement' in nineteenth-century culture.

The 1867 text was published in its entirety for the first time in 1970, in the edition of Cros's work published by the Bibliothèque de la Pléiade.[88] Curiously, the silence of the Académie des sciences has extended into the historiography of cinema and of its 'precursors', in which 'this prophetic text,

86 See Ariane Isler-de Jongh, 'Inventeur-savant et inventeur-innovateur: Charles Cros et Louis Ducos du Hauron: Les commencements de la photographie en couleurs'.

87 *Comptes rendus hebdomadaires des séances de l'Académie des sciences*. The note is unsigned.

88 Tristan Corbière and Charles Cros, *Oeuvres complètes*, 493-498. (These 'complete works' were not complete, as shown by the later publication of several previously unpublished texts.) In Cros's *Oeuvres complètes*, published in 1964 by Jean-Jacques Pauvert, there appeared, under the title mentioned here, only the excerpts published by the *Comptes rendus*. At the same time, this text would be reprinted in its entirety in 1972 in the otherwise slim dossier of scientific texts found in Louis Forestier's volume *Charles Cros*.

dazzling with intelligence (Cros foresaw colour cinema),' as the editors of these complete works[89] describe it in now-familiar terms, is to my knowledge never mentioned. At best, and only rarely, Cros figures in histories of 'pre-cinema' only for his research into sound.[90] Although it is easily accessible, and despite the stature of its author, Cros's contribution continues to be unknown in the field.

We should recall that when he wrote this text Cros was 25 years old. He had already worked in various fields, from teaching the deaf to a fine 'musical stenography' *dispositif* patented in 1864. He also obtained a patent for a notable improvement to telegraphy in 1866, which was presented at the 1867 World's Fair. There followed, most notably, two publications, the first in 1869 on colour photography, *Solution générale du problème de la photographie des couleurs*.[91] The second, in 1877, concerned a 'means for recording and reproducing phenomena perceived by hearing,' which he called the Paléophone.[92] The title of the 1869 text is of particular interest to us here: at this moment, 'colour photography' can be seen as a *problem* recognized as such by the community of researchers and a number of amateurs belonging to the general public. The problem is constituted by stating the expected result and by the range of partial or particular solutions that had been formulated by that date, with this text asserting that it would bring, finally, an 'overall solution.' Once again, the problem does not suppose, in the minds of researchers and amateurs, any preconceived idea of colour photography, or of photography in general; it does suppose, however, a certain historical orientation of the research, the tension towards a forthcoming solution, which implies in its historical movement a form of teleology operating without hindsight.

Before examining the text of the sealed letter of 1867, it seems necessary to mention a few features of other inventions by Cros related to our questions, directly or indirectly. On 10 May 1864, Charles Cros and his brother Antoine

89 Ibid., 1219.

90 This is true in particular in the work of Jacques Perriault, who does not hide his admiration for the poet and inventor and devotes a major section of his chapter on the 'memory of sound' to him. See Jacques Perriault, *Mémoires de l'ombre et du son: Une archéologie de l'audio-visuel*, 134-176 in particular.

91 Paris, Gauthier-Villars and the newspaper *Les Mondes*, 1869. An initial version of the text was first published in *Les Mondes*, the newspaper of Abbé Moigno, vol. 19 (25 February 1869): 303-311; *Solution* was then partially reproduced in the *Bulletin de la société française de photographie* (vol. 15 [1869]: 185-195), along with a number of articles on the concurrent principles of 'héliochromie' described by Ducos and Cros interspersed throughout the volume.

92 For the scientific work, see Charles Cros, *Inédits et documents*.

filed a patent application for 'musical stenography procedures and new devices for the exact graphic representation of music performed on keyboard instruments.'[93] The centrepiece of the patent, claimed to be 'either new applications of known laws, or better realizations of earlier conceived ideas,' was both 'the idea of obtaining, as much as possible, an *exact* representation of the music played' and 'the various kinds of devices, whether described in the present statement or drawn on the plates enclosed herein, as well as all the new organic details indicated as such in this work, and the planned modifications which will make it possible to vary their form and dimensions according to secondary conditions of ease of use, placement, [etc.].'[94] He was thus protecting at one and the same time an overall project, specific innovations, new possibilities, or simply 'better' technical applications. By 1864, these issues of musical recording, 'a means of some kind of recording sounds,'[95] already had a considerable history, in particular in preceding years with the contributions of Édouard-Léon Scott de Martinville.[96]

The precise problem the Cros brothers formulated as central was that of the *accuracy* of the 'representation', which for them was connected to the question of the mechanical rubbing that altered the strict regularity of the speed at which the base strip advanced: 'This accuracy [of their invention] is due primarily to the uniformity of the continuous movements employed so that they are no longer broken up by variations caused by rubbing'.[97]

The production of plotting *dispositifs* connected mechanically to keyboard instruments without any frictional variation on the inscribing base was thus the site of inventors' technical reflections, the specific problems for which the devices described in the patent applications were the solutions. The Cros brothers describe two 'kinds of device'; the first was a 'mechanical transmission system' and the second a 'system based solely on the chemical action of galvanic currents.'[98] The way the patent application was written itself shows that intellectual property had to be claimed both on the problem and on the solution:

> It is necessary that these [transmission] levers move silently, something that is easy to achieve with flannel lining [...]. It is also necessary that

93 French patent no. 62,974. Reprinted in Charles Cros, *Inédits et documents*, 60-65.

94 Ibid., 65. Emphasis in the original.

95 Note by Pierre E. Richard in ibid., 65.

96 On these issues, see Patrick Feaster, *Pictures of Sound: One Thousand Years of Educed Audio: 980-1980*.

97 Charles Cros, *Inédits et documents*, 60.

98 Ibid., 61 and 64.

> their position vary little, something we have achieved in executing our idea [...]. In addition, it is indispensable that their bearing points be immobile [...]. A small iron pivot [...] is the means chosen by us to fulfil this condition.[99]

It was the *quality* and the *form*, precisely, of the movement of the base strip that interested the Cros brothers here. The underlying system, but also the ways of thinking adopted, pertain fully to the epistemological framework of Marey's 'graphic method'[100] with the crucial exception that the goal was not to analyse motion but 'stenography', recording, the trace and the traced, which would create a document but not a base for quantitative examination: 'The fourth organic part of the device is intended to employ the action of a graphic system, in uniform and continuous motion, a strip of scored paper [...] on which the traces corresponding to the sounds must be gathered and fixed'.[101]

One of the options proposed for the construction of these strips was photographic. 'Transmission levers' attached to the keyboard's keys opened 'holes or windows in an opaque partition'. On one side of this partition was placed 'a lamp with or without a reflector' and 'behind this partition and on the path of the rays of light is a strip of paper, or any other surface, which is sensitive to light and turned by a clockwork system.'[102]

The action of the keys would thus produce 'beams of light which would impress the photographic surface without in any way interrupting or slowing down its movement.'[103] Photography is an interesting element of the patent application, not only because it creates a trace, reacting immediately to the phenomenon – 'the photographic surface [is] sensitized in such a way as to leave instantaneous marks', a sensitization that could and should be carried out 'by well-known processes.'[104] In addition, it acts from a distance, i.e. without any friction, being completely unable to alter the speed of the base strip. It also made possible an 'optional and unlimited [...] reduction' to the point, if necessary, of being made 'microscopic' by a converging lens. Here, we see the theme of photographic reduction later found in the 1867 application.

99 Ibid., 61.

100 This is discussed most notably by François Dagognet in *Étienne-Jules Marey: La passion de la trace*.

101 Charles Cros, *Inédits et documents*, 63.

102 Ibid.

103 Ibid.

104 Ibid.

The ideas of a constantly moving strip, of blocking exposure to the light, and of a photographic base making possible an inscription in time[105] were shared by this procedure and the exactly contemporary procedure of Ducos. Indeed, these stenographic devices of 1864 were closer in numerous respects to Ducos's *dispositif* than they were to the 'procedure for recording and reproducing colours, forms and movements' of 1867. Despite everything, we see the extent to which the elements of this set-up were organized in a completely different manner by Cros than by Ducos.

On 2 March 1867, Cros wrote an 'explanatory statement attached to the request for an addition certificate to its invention patent,' the patent filed the previous year for an 'autographic telegraph with non-independent combined movements and using a single cable.' In it he described 'how the possibility of instantaneously and periodically stopping the corrector disc A was achieved […] and consecutively the tracing point that this disc controls.'[106] He thus had to think about a mechanical system of tracing and intermittence for a completely different object than an image or the voice.

Later, in a sealed letter filed with the Académie on 14 January 1878, Cros explained a 'technique for recording and reproducing telephone vibrations.' At its basis was an inscribing stylus with 'a uniform layer of a silver compound easily reducible by electricity. Photography provides us with numerous fine methods for this.'[107] Next, as in photography, one would develop and fix the 'picture', the sensitive layer having been deposited on a rotating vertical cylinder. And, as in phonography, 'it is enough […] to pass this trace once again under the blunt point' and to place a telephone in the circuit for the original signal to be repeated.[108] We are thus in the presence of a kind of 'responder-recorder' that, in fact, is conceived as a kind of montage of two existing kinds of machinery, one visual and the other audio, working together through the intermediary of electricity – an 'electric photographic phonograph'. To this was added a corollary advantage of photographic procedure: reproducibility: 'If one fears the too-rapid destruction of the picture through the repeated friction of the blunt point, nothing stands in the way of taking as many photographic copies of it as one wishes if the picture is flat'.[109]

105 The parallel with the 'organ cylinders known as *barrel organs*' is mentioned explicitly by Cros in ibid., 65.
106 Ibid., 73.
107 Ibid., 97.
108 Ibid., 98.
109 Ibid.

Finally, Charles Cros filed a joint patent application with Jules Carpentier on 17 November 1880 for '*the improvement of telegraph lines*, applied to long-distance telephony.'[110] The engineer and inventor Carpentier, who, as we shall see, would play an important role in the invention of the Lumière Cinématographe, was a close friend of Cros, as illustrated in the poignant correspondence between them in 1886 and reproduced in the Cros volume *Inédits et documents* edited by Pierre E. Richard.[111]

Before then, however, the 1867 application, which has more interest for us here, bore the title 'procedure for recording and reproducing colours, forms and movements.' Several aspects of this title are already worth noting. First, movement is named last: the heart of the question is colour. Next, Cros identifies two possible moments or tasks: recording and reproduction. The former is not the mere corollary of a *dispositif* oriented towards the latter: these are, by definition, two *distinct* uses, as the document makes clear in the first sentence: 'The possibility of recording scenes in motion, and that of their optional reproduction, is very easy to understand'.[112]

It was thus a question of being able to record 'scenes in motion' with an archival aim and then, possibly, to reproduce such scenes at will. This was a project, by definition, different from that of reproducing 'characters in motion' announced by Du Mont in Michel Frizot's quotation, and even from 'any scene, with all the *transformations* it has undergone' (my emphasis) in Ducos's formulation. From our perspective, it is also important that Cros viewed this possibility as 'very easy to understand.' Why was it so easy? Because it was only a matter of bringing together two already familiar procedures: on the one hand, 'the toy invented by Mr. Plateau, which he called a Phenakisticope,'[113] and, on the other, photography. One can already see here that the project outlined by Cros is not at all ahistorical or timeless in keeping with an 'idea' of 'cinema': its very conception was explicitly made possible by two recent technical inventions.

From the outset, Cros's formulation was at a remove from that of Ducos, which Cros gives no indication of being familiar with. Ducos mentioned no optical toy, nor did he mention the Phenakisticope, and he granted only

110 'Perfectionnement des lignes télégraphiques: Téléphonie à grandes distances par MM. Jules Carpentier et Charles Cros', French patent no. 139,684, 17 November 1880, in ibid., 89.

111 Ibid., 84-87.

112 Charles Cros, *Oeuvres complètes*, 493. We should note here that the dual mention of recording and reproduction was fairly common in patent applications of the day, but here the distinction is accentuated by Cros, who does not bind them together but treats them as two tasks of different rank and staggered in time.

113 Ibid.

a limited role to the persistence of vision. For Cros, the existence of the Phenakisticope is presented as the fundamental key that already poses and resolves the problem of reproducing movement.

This project of innovating by means of joining corresponds exactly to Bachelard's descriptions of the first stage of formulating a problem, when, in Canguilhem's summary, 'one thinks one is explaining a problem by alternating analogies one after the other.'[114] This project also fits exactly with Simondon's description of the primitive mode of existence of technical objects – the 'abstract' form in which the new object is conceived, not according to its still unknown inherent logic but as an arrangement, a montage, of already familiar objects: 'integration into an ensemble in this case raises a series of so-called technical problems that must be resolved and are in fact problems of compatibility between already given ensembles,' he wrote.[115]

What astonished Sadoul the most – and by ricochet Bazin – in this initial phase of research that 'foresaw' cinema in the years 1850-1860, is that cinema was conceived before the technical conditions of its realization – and thus, for them, its *conceptual* conditions – were conjoined. It appears that it is necessary, for cinema to be *conceived*, that instantaneous photography – or even the succession of photographs on a flexible transparent strip – already be a fact, which was not true of those years. It appears that history must advance logically, step by step, with each invention or discovery made possible and sparked by the former. If a transparent flexible base is a technical condition of the possibility of 'cinema', then it appears that it is necessary that this base exist for 'cinema' to be conceived. If this were not the case, it would mean, according to them, that 'cinema' must be one of those ideas born with humanity.

This was thinking with hindsight, at a moment when 'the solution found reflect[ed] its clarity on the facts' – a way of thinking that forgets, as Bachelard wrote, that 'historical order does not necessarily follow the line best adapted to discovery. It is only after the fact that one understands the true hierarchy of the problems.'[116] Before the solution is found (and, naturally, there are always several possible solutions within an overall framework of possibilities), the problem was posed differently and other solutions

114 Georges Canguilhem, 'L'Histoire des sciences dans l'oeuvre épistémologique de Gaston Bachelard', 174.

115 Gilbert Simondon, *The Mode of Existence of the Technical Object*, 27.

116 Gaston Bachelard, *Étude sur l'évolution*, 94.

were proposed according to the technical and epistemological conditions and givens available at the time. When Cros was writing, 'instantaneous photography' did not exist as an *idea* independent of photography, and – unlike Ducos three years earlier – he did not use the expression a single time in his text. But this did not prevent him from conceiving a solution to the problem he set himself. For while Ducos did not discuss the question of the necessary sensitivity of the collodion, supposedly resolved by the very expression 'instantaneous prints', Cros was perfectly aware of the primordial requirement of having '*fast*' emulsion. Once he made the connection between the Phenakisticope and photography, he immediately remarked: 'We know that present-day photographic procedures make it possible to obtain prints in very small fractions of a second, and that this rapidity increases as the image size is reduced'.[117]

Here, Cros is banking on a familiar photographic phenomenon at the time: 'the connection between a reduction in the exposure time and a reduction in the format,' a partial solution to the problem of 'instantaneous' photography before a general technical solution existed, one adopted by numerous photographers. Both Michel Frizot and André Gunthert note this procedure, varying in their technical explanation and their account of its visual results,[118] but there is one constant element in their accounts: using small formats made it possible to reduce the exposure time required to obtain a sharp image. Today, we must unlink the notion and practice of 'instantaneous photography' from the chemical process with which it is too systematically associated, *in retrospect*: silver gelatin bromide.

The elegance of Cros's solution derives from its use of 'microscopic photography' to resolve *simultaneously* the problem of rapidity and the problem of the great number of 'elementary tableaux' required. This simultaneity was already a step towards making the machine concrete in Simondon's sense, whose 'process of concretization' is recognizable in particular when 'each structural element fulfills several functions':[119]

> The mechanical and practical realization of the problem thus posed [that of the *dispositif* proposed, whose expected results Cros had just described] is remarkably facilitated by the use of microscopic photography (the simple

117 Charles Cros, *Oeuvres complètes*, 493.

118 André Gunthert, 'La Conquête de l'instantané: Archéologie de l'imaginaire photographique en France (1841-1895)', 142 (where the expression quoted can be found); and Michel Frizot, 'Speed of Photography: Movement and Duration', 244.

119 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, 36.

> or solar microscope to make the photographs of suitable dimensions). In fact the elementary tableaux, whose number must often be very great, will contain everything on relatively very small surfaces. A fragmented plate ten centimetres in length can contain more than 10,000 such tableaux (giving each print a square millimetre of surface) to depict a scene in a thousand seconds, or sixteen and two-thirds minutes at a rate of ten prints per second.[120]

This fascinating passage elicits several remarks. First, early in the paragraph Cros speaks of a 'problem thus posed.' This text, which claims to be new because it was filed by its author with the Académie des sciences, should thus have begun by posing a problem, which, according to Cros, constitutes the goal of the previous part of the text. To synthesize the problem, it is not constituted solely by expressing the expected results – 'the recording and reproduction of colours, forms and movements' – but by an ensemble that includes this assertion of the results; the insistence of their interest and novelty, as well as on a range of possible applications; the theoretical principles through which the question is addressed – combining the Phenakisticope and photography; and the technical-theoretical principles that will make its concrete realization possible and that spell out the inventor's approach – the use of 'microscopic photography'. The problem cannot be seen to be posed concretely without the conjunction of these three elements, which underlie the rhetoric peculiar to patent applications. A problem is not simply an idea, a result or a 'project', possibly 'underlying';[121] it is a construction that re-orders the entire 'general system' (Bachelard) and that is theoretical, technical, and epistemological. Based on these premises, it remained for Cros to describe the solution to his problem, its 'mechanical and practical realization', its being put to use in a technical manner, the moment of its invention. But we can see clearly that the terms of this solution are already partially in play through the manner in which the problem is precisely posed.

Next, note that Cros envisions recording a 'scene in motion' of long duration – more than sixteen minutes – at a speed of ten images per second. Here is where 'microscopic photography' constitutes a solution to two problems at once. In addition, there is no mention of a flexible base, or of an element whose form would be reminiscent of a strip. Sadoul's logic that the zoetrope was an important moment because the arrangement

120 Charles Cros, *Oeuvres complètes*, 494.
121 See the remark by François Brunet in *La Naissance de l'idée de photographie*, 31.

of images in sequence on a flexible strip 'foresaw' cinema is thus eluded: the sole reason Cros takes the Phenakisticope as his explicit starting point is because of its underlying principle. In no way does he conceive of his procedure as pertaining to the 'technical lineage', or the conceptual lineage, of optical toys (brief scenes, repetitive nature of the tableaux in motion, etc.). Can we, likewise, say that the epistemological framework in which Cros is thinking is strictly photographic? This is not clear. In the logic of the machine, for example, there is not a base, or plate, for each 'elementary tableau', as was the case in other proposals of the day, in particular that of Du Mont. As in Ducos, there is a *single base for the entire series*. The vocabulary Cros uses and the microscopic size he does not hesitate to ascribe to his 'elementary tableaux' confirm that, for him, as for Ducos, the fundamental thing truly is the 'scene in motion' and not the fixed images that constitute it.

Another important question for understanding the evolution of the 'cinema' problem is one already raised by Ducos's patent application: where the projection would take place. This question is not explicitly addressed in this section of the text – Cros discusses it in the subsequent chapters, devoted to colour. Photography does not presuppose projection. Yet, projection is suggested by the idea that a 'solar microscope' could be used to make the images 'of suitable dimensions', which are not specified. In any event, the theme of a 'large audience' – the eyes of 'an entire assembly' – does not appear here.

Finally, it is striking to note the persistence in Cros's vocabulary of the notion of *ease*. This term recurs several times throughout this section devoted to the problem of 'scenes in motion'. In retrospect, this ease contrasts strangely with the historical gap between this 1867 text and the moment when a machine able to record and reproduce scenes in motion took concrete form. This would take more than twenty years, during which time the problem would undergo profound modifications and be adopted on completely different technical, theoretical, and epistemological bases.

This recurring ease is not solely the effect of a kind of dandyism on the part of Cros the poet. It is also connected to the fact that this 'possibility of recording scenes in motion, and that of their optional reproduction' is in fact not the central problem of Charles Cros. This interests him very little; his problem is that of colour. In the second section of the text, on the topic of colour, Cros acknowledges more readily the complexity of the matter. Colour synthesis in particular, once the three-colour separation is carried out, was not easy to think up. But one means did exist:

> The superimposition of three positives, run through with red, yellow and blue rays respectively, would appear to present a few difficulties. But these difficulties disappear if one substitutes for real superimposition a rapid succession of three differently coloured projections in the same place.[122]

In this way, the solution to the problem of colour photography lies in picturing a procedure that would make possible the rapid succession of projected images and their melding by means of 'the persistence of vision'. This, moreover, was the principle that made it possible for research into colour cinematography to outpace colour photography in the early years of the twentieth century. But that is another story, one that would lead to Kinemacolor. In any event, on this basis, Cros could easily combine the solutions to these two problems to imagine the colour recording of scenes in motion, because, in fact, these two solutions were just one, as the question of movement was merely corollary to the problem of colour.

Cros would explain this connection between these problems and clarify what, for him – and we might say for his age, if we believe the reception of the text by the Académie des sciences in 1867 – was the most important of these two questions, on colour and movement. In 1869, he published his *Solution générale du problème de la photographie des couleurs*, which, concurrently with Ducos du Hauron's contribution, had a large impact. Two years after the sealed letter of 1867, Cros made no mention at all of the question of photographing movement, and he would never return to the matter, despite tenaciously championing other ideas and inventions he considered important. In fact, the 'scenes in motion' had disappeared, but not the Phenakisticope. For the 1869 publication – a more complete resolution and clearer formulation of the 'problem of colour photography' than the 1867 document – ranked 'successive synthesis' first in its presentation of the various possible procedures for synthesizing colours, stating that 'the Phenakisticope, brought back into vogue lately under the name zoetrope, excuses me from long explanations.' The rapid succession of three coloured selections would create the desired effect. This procedure applied to 'projections on a screen, to transparent positives and to positives viewed directly,' arranged on a simplified three-picture Phenakisticope. At the same time, the theoretical model shifted towards another slightly different device: 'it is hardly necessary to state that the principle of this successive synthesis is experimentally demonstrated by the turning disc with coloured sections.'[123]

122 Charles Cros, *Oeuvres complètes*, 495-496.

123 Charles Cros, *Solution générale*, 7-8. Emphasis in the original.

Isaac Newton's discs and its numerous variants in the nineteenth century thus took the place of the principle behind the Phenakisticope, bringing about a significant shift in focus.

The 'Cinema' Problem

Is the problem of Charles Cros, or his problems in the plural, the 'cinema' problem?

In the first section of his 1867 text, he presents the range of possibilities of his 'procedure': 'Theatrical scenes, fairy tableaux, ballets, street scenes, battle episodes, storms, hunts, official ceremonies, races, regatta, etc. will be fixed in all their peripeteia and reproduced in their gripping reality'.[124]

How, retrospectively, should we read such a sentence, with its list that would not mar a Gaumont, Pathé, or Edison programme or catalogue, without wanting to date it to 1898 or to 1907, if the verb were not in the future tense? To conclude that Cros was a precursor, anticipating cinema but prevented by the state of techniques in his day, is tempting. But this does not allow us to problematize a concrete and precise historical situation, or the questions it raises for the history of techniques, the media, and ideas, other than to highlight Charles Cros's genius. What is of concern to us is an understanding of the evolution of a problem whose issues are inseparably theoretical, technical, and epistemological. The similarity between the form and content of this list and the even longer list developed by Ducos confirms the existence already in the 1860s of a real or imagined iconography of movement, whose motifs and topoi were already profoundly a part of the culture of the day.

The text filed by Cros in 1867 connects a series of problems: primarily, a proper problem – the problem he formulates and sets out to resolve – whose singularity and coherence must be understood precisely. But this problem did not exist on its own. Firstly, we might ask ourselves whether Cros was aware of the few prior attempts in the field of recording and reproducing movement – that of Ducos and those of the others mentioned by Frizot in particular. The profound difference in the logic of the solutions proposed, but also and above all in the way the problem was formulated, lets one suppose that there existed a circulation of ideas not tied to a direct reading of the texts, but rather to a general context arising out of partially shared sources. In addition, however, the

124 Charles Cros, *Oeuvres complètes*, 494.

problem developed in the 1867 text was connected to the 'overall system', the conceptual framework in which Cros operated, which situates this 'procedure' alongside his inventions, devices, theories, and perhaps poems. Here, for example, we see the importance he grants to *reducibility* as the fundamental nature of the photographic image, but also his ability to see photographic recording as a singular way to inscribe traces (part of the graphic method) and to organize it with electrical phenomena and with sound recording *dispositifs* (and possibly sound reproduction *dispositifs*) – musical stenography or telephonic recording. Research into three-colour photography would become independent in Cros's work, producing the 'overall solution' of 1869, but in 1867 it had to pass through a model that conceptualized it within the framework of movement, with the conceptual tools of the 'Phenakisticope principle'. The problem of photographing movement thus appears to be a *moment* in the problem of photographing colour.

This problem, elaborated in Cros's patent application, can also be seen as another moment in the 'abstract phase' of a broader problem that saw several clearly distinct incarnations and yet constitutes its own set of issues – a complex, non-linear descent alternating between continuities and ruptures, in every era branching off in multiple directions, and definable according to criteria we would do well to specify. It is thus not a question of reducing or ignoring but of measuring, firstly, for each singular problem and solution, the gaps between them and the overall problem – gaps of hypotheses, methods, projects, issues, and the forms of the solutions proposed – and, secondly, the potential fruitfulness of these gaps by means of a precise technological and epistemological analysis of machines and discourses.

This overall problem should be called 'cinema', even though the term is fiercely anachronistic, because this term alone, placed in quotation marks to remind us that it is the name of a problem being elaborated and not that of culturally constituted machinery, can designate in a simple manner the central point of this complex and heterogeneous ensemble of singular research activities. It can designate this point only because there 'cinema' is conceived solely as a problem and not made official or essential as an idea whose definition is stable and the subject of consensus. Researchers need problems, not ideas. The anachronistic nature of the word 'cinema' problematizes the question historiographically in a way in which, like the case outlined by Bachelard, the reconstruction of the initial complexity of the problem as it is posed in all its specificity to the researcher can only be carried out from the period when 'the solution found reflects its clarity on the facts' – even if, in the history of techniques, contrary perhaps to the history of science, the solution is never singular or definitive. Ultimately, we can only return here to the principles set out in a different era by Walter Benjamin:

> Addressing himself to the historian who wishes to relive an era, Fustel de Coulanges recommends that he blot out everything he knows about the later course of history. There is no better way of characterizing the method which historical materialism has broken with.[125]

125 Walter Benjamin, 'On the Concept of History', 391.

4. The Invention of the Cinématographe

Abstract
When the Lumière Cinématographe was invented, was cinema invented too? And was the Cinématographe a true invention, or only an innovation within an ensemble of machines already established by 1895? These are certainly among the most debated questions in the historiography of cinema, and in its technological historiography in particular. They reappeared on a regular basis, in particular at the time of 'anniversaries' of the invention (1925, 1935, etc.), before being revived for other reasons by the transformation to digital encoding. This chapter reconsiders the Cinématographe's status within the history of film technology, questioning whether it is an invention and where its newness may be situated. From its cams to the evolutions of its shutter, from its crank to its reversibility, from its relations with amateur photography to its relations with Marey's chronophotography, the famous Lumière machine is reconsidered within its cultural, scientific, and technological contexts.

Keywords: Cinématographe, Louis Lumière, Thomas Edison, film technology, film camera, film historiography.

The Cinématographe and the Question of Invention

When the Lumière Cinématographe was invented, was cinema invented too? And was the Cinématographe a true *invention*, or only an innovation within an ensemble of machines already well in place by 1895? These are certainly among the most debated questions in the historiography of cinema, and in its technological historiography in particular. They reappeared on a regular basis, in particular at the time of 'anniversaries' of the invention (1925, 1935, etc.), before being revived for other reasons by the transformation to digital encoding.

An initial response to these questions has been proposed, for example, by André Gaudreault in his article 'On Some Limitations of the Definition of

Turquety, B., *Inventing Cinema: Machines, Gestures, and Media History*. Amsterdam: Amsterdam University Press, 2019.
DOI 10.5117/9789463724623_CH04

the Dispositive "Cinema"': it points out the indisputable difference between the cultural phenomenon *cinema* and the *Cinématographe* (Illus. 26), which is, 'basically and quite simply […] only […] a machine to shoot views – extraordinary and brilliantly designed, to be sure, but a machine all the same.'[1] When cinema was invented is essentially a poor question, a false problem: 'Who invented cinema? Answer: the cinema cannot be invented (there is no patent to be registered): it becomes *established*, gradually and collectively'.[2]

Thus, whether the Cinématographe was an invention in the technical sense of the term has played no role in a history of cinema. It is interesting to note, by way of contrast, the extent to which the question of the *invention* of cinema, and whether the Cinématographe was really an invention or not, has played an absolutely crucial role in the historiography of cinema. We may see in this the cultural dominance of a linear conception of history, the need to idolize brilliant inventors, etc. But cinema – a cultural construction, or as François Albera proposes a paradigm – initially saw itself as an invented technical form, the product of modern mechanics and chemistry, and even electricity. Cinema's history shows that it is tied to an imaginary of technics and of the machine and its avatars, and thus of the invented. This is why, beyond the mere technological interest of the question of the invention of the Cinématographe, it appears to me that an epistemological reconstruction of cinema, both at the time of its emergence and afterwards, and an understanding of the technical, aesthetic, perceptual, and historiographical issues related to cinema, cannot overlook a technology of its invention – and, in particular, of the Cinématographe as the consensus moment of its invention – in order to examine the issues raised.

What is required, then, is to ask ourselves what, in the Cinématographe, ultimately *constituted an invention*?. The imaginary of invention will lead force us to show a precise moment of invention, a material element, a concrete place that is the *there* of the new and the never before seen. This new can only establish itself in relation to the constellation of the existing, as Panofsky remarked:

> An innovation – the alteration of what is established – necessarily presupposes that which is established (whether we call it a tradition, a convention, a style, or a mode of thought), as a constant in relation to which an

1 André Gaudreault, 'On Some Limitations of the Definition of the Dispositive "Cinema"', in François Albera and Maria Tortajada, eds., *Cine-Dispositives: Essays in Epistemology across Media*, trans. Franck Le Gac (Amsterdam: Amsterdam University Press, 2015), 170.

2 Ibid., 178.

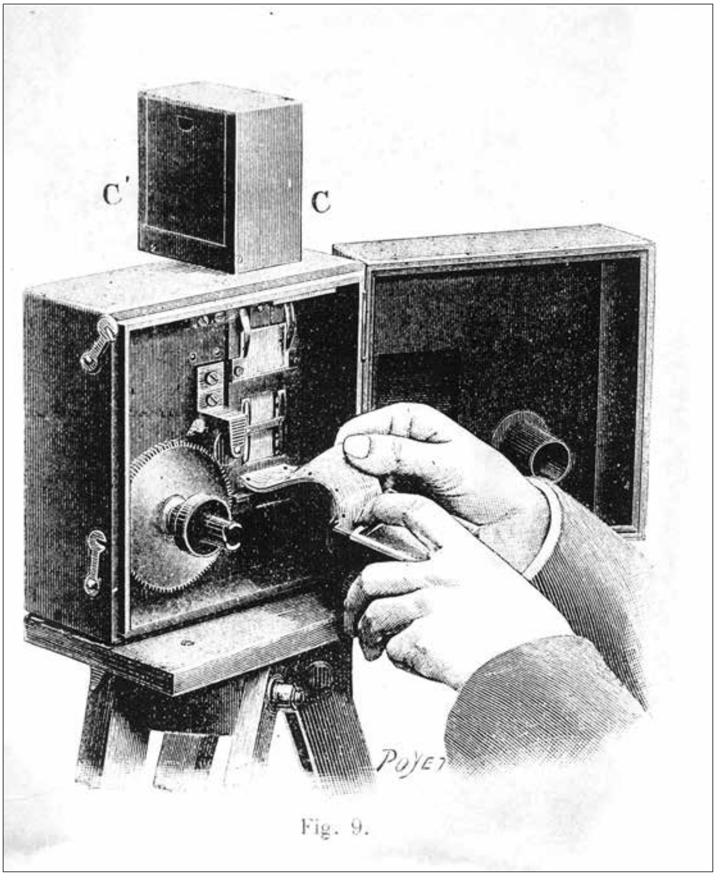


Illustration 26 – The Lumière Cinématographe, open. Loading the film. Notice, 1897.

> innovation is a variable. In order to decide whether or not an 'individual's solution' represents an 'innovation' we must accept the existence of this constant and attempt to define its direction. In order to decide whether or not the innovation is 'influential' we must attempt to decide whether the direction of the constant has changed in response to the variable.[3]

This constellation of the existing is, in the case of the Cinématographe, composed of two major stars in historiographical debates of the day: Thomas Edison's Kinetoscope and Étienne-Jules Marey's Chronophotographe. Here, for example, is how Albert Londe, as early as 1896, denied the Cinématographe, 'above all a financial affair,' any fundamental contribution:

3 Erwin Panofsky, *Renaissance and Renascences in Western Art*, 2.

> The Lumière brothers, taking good advantage of the ideas of their predecessors and bringing them together, have produced a device about which much has been said: the *cinématographe* [...]. It is based on the principle of stopping the film, which indisputably belongs to Marey, and uses strips of a certain length, which Edison had already done. It thus contains no new idea.[4]

Eugène Trutat, in his 1899 volume *La Photographie animée*, considers the same constellation, but in a subtler manner establishes a difference, one that is not strictly mechanical, but rather technical and commercial. What the Lumière brothers invented was, in the first place, projection:

> As always, Edison introduced numerous modifications in his Kinetoscope, and initially was content with devices for direct viewing. He did announce that he had achieved life-sized projected images, but this device was unknown in Europe when the Lumières brought out their Cinématographe. Its mechanisms were completely different from those of the Kinetoscope, and for the most part also different from Mr. Marey's Chronophotographe. But on the whole it was still just a modification of the earlier invention.[5]

This is undoubtedly the most persistent historiographical topos. What must be credited to the Lumière brothers, what may make them the inventors of cinema (and not simply of the Cinématographe), is the idea and achievement of showing moving photographic images in the form of a projection '*to an entire assembly* of viewers,' as they themselves wrote.[6]

The Site of the Invention

In 1922, Félix Regnault made reference to a slightly different constellation. For him, the fundamental machine was the Chronophotographe, with moving film, a machine whose perfection he dated to 1888:

> Then came those who would improve it. The cam and the perforation were the two major improvements.

4 Albert Londe, *L'Industrie progressive*, 4 July 1896. Quoted by Georges Sadoul, *Histoire générale du cinéma*, vol. 1, *L'invention du cinéma, 1832-1897* (Paris: Denoël, 1946), 217-218.

5 Eugène Trutat, *La Photographie animée* (Paris: Gauthier-Villars, 1899), 60.

6 Louis and Auguste Lumière, 'Le Cinématographe', *La Revue du siècle* 11, no. 120 (May-June 1897): 234. Emphasis in the original.

> The cinema cam was invented by Georges Démeny [*sic*], it stopped the film more gently and started it less abruptly than Marey's claw.
> Perforation was discovered by Émile Reynaud, inventor of the Praxinoscope and the optical theatre. It was issued patent no. 194482 on 1 December 1888.
> (. . .)
> In 1895, the Lumière brothers perfected cinema 2 [which *synthesized* movement, in contrast with cinema 1, which *broke it down*] and made it commercially viable. They used perforations, got rid of the Démeny cam, and finally – and this is what constitutes the originality of their discovery – invented a pair of claws to which they communicated a dual back and forth movement by way of the Trézel cam or Lumière cam. The claws grab hold of the holes in the film, accompany it as it moves downwards, and then leave it when it stops. In this way the stoppage is long enough to ensure good illumination and make it possible to project the film onto a screen.[7]

In Simondon's dichotomy between invention (a major, discontinuous transformation) and innovation (a minor and continuous improvement), the Lumière brothers, for Trutat and Regnault, fall on the side of innovation: they modified, they improved, they brought together already existing *dispositifs*. Naturally, Trutat acknowledges that their 'mechanisms were completely different' from those of their rivals, but this was just a detail of their 'internal' technical achievement and changes nothing about the matter in concrete terms. They were granted one original thing, related to the *principle* of *projection* on the one hand and with its *technical mode of realization* on the other – and the kind of exhibition and form of entertainment tied to it. From this perspective, the most commonly agreed upon date for the 'invention of cinema', at least among French speakers, is 28 December 1895, or the date not of the invention of the machine, but rather the date of the Cinématographe's first public, paying projection.

As far as the Lumières' mode of creating their device technically, in the end it was a precise technical element which would, in the historiographical tradition, become the *site* of the invention. More precisely still than the 'system of claws', this element was described by Regnault as 'the Trézel cam or Lumière cam' (Illus. 27). Summarizing this position, André Gaudreault remarks that 'the Lumière brothers thus owe this cam their reputation in history as the inventors

7 Félix Regnault, 'L'Histoire du cinéma: Son rôle en anthropologie', *Bulletins et mémoires de la Société d'anthropologie de Paris* 7, vol. 3 (1922): 63.

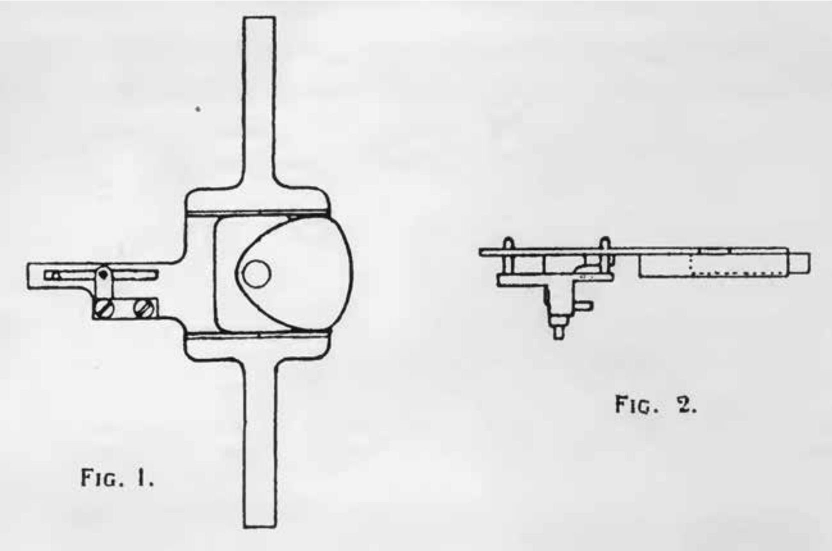


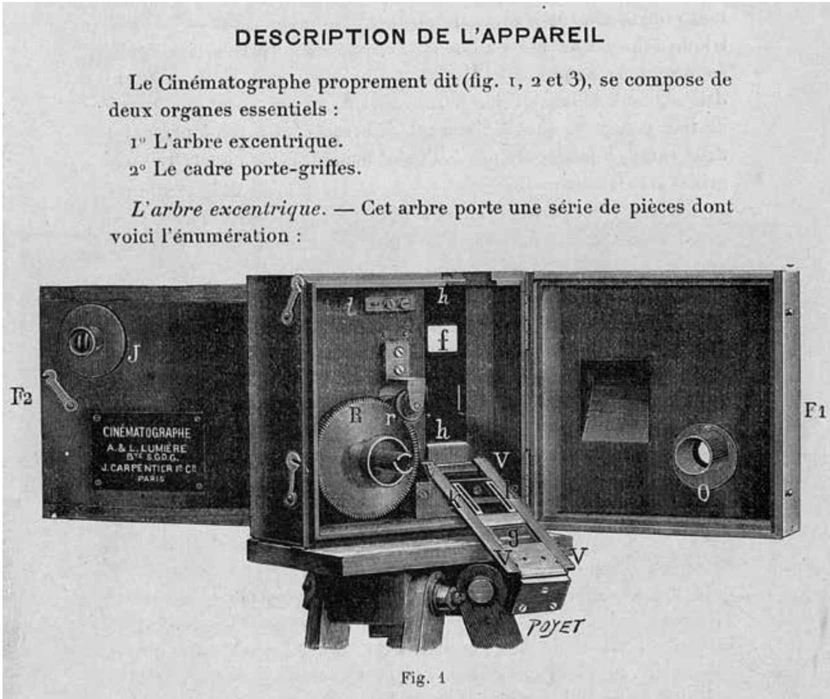
Illustration 27 – Eccentric cam and claw frame. Louis Lumière, 'The Lumière Cinematograph', JSMPE 1936.

of the *cinema*.' The Cinématographe's eccentric cam, '*primum movens*', was the 'dispositive-thingy of the Lumière brothers [which] proved priceless for them.'[8]

The cam did not get its name by chance, for several reasons. The first is that it was presented by the Lumière brothers themselves in 1897 as the key element of their contribution; in the *Notice* accompanying their device when it was put on the market they described the '*alternating movement* given to the frame under the impetus of a *triangular cam, an arrangement which is the fundamental element of our patents*.'[9] Next, the cam was the mechanical site of the device's *intermittence*, that fundamental feature of cinema's episteme and technical imaginary. The irregular shape of this cam was behind the movement-stoppage dialectic that became the technological and epistemological foundation of 'cinema' (Illus. 28). Even as cinema employs the 'Phenakisticope principle', insofar as it creates the illusion of continuous movement out of a series of fixed images, it introduced a major shift to this principle. It was no longer enough to put the machine in

8 André Gaudreault, 'On Some Limitations of the Definition of the Dispositive "Cinema"', 169-170.

9 Louis and Auguste Lumière, *Notice sur le Cinématographe* (Lyon: Société anonyme des plaques et papiers photographiques A. Lumière et ses fils, 1897), 5. Reprinted in *La Revue du siècle*, 236, and quoted by G.-Michel Coissac, *Histoire du Cinématographe: De ses origines à nos jours* (Paris: Cinéopse/Gauthier-Villars, 1925), 176. Emphasis in the original.



DESCRIPTION DE L'APPAREIL

Le Cinématographe proprement dit (fig. 1, 2 et 3), se compose de deux organes essentiels :

1° L'arbre excentrique.
2° Le cadre porte-griffes.

L'arbre excentrique. — Cet arbre porte une série de pièces dont voici l'énumération :

Illustration 28 – The Lumière Cinématographe. Beginning of the description of the device. Notice, 1897.

motion, or for the machine to produce movement around the images; it was necessary for it to create both movement *and stoppage*. Neither Cros, nor Ducos employed either the concept or the idea; they were not a part of the problem's conceptual framework at the time. Beginning with Marey, this point would be a central focus of innovations, with each inventor offering his own solution for the best way to achieve intermittence: the compressor with pins of Marey's film Chronophotographe; the beater-movement cam invented by Georges Demenÿ; the Maltese cross used for the first time, according to Charles Francis Jenkins,[10] by O.B. Brown in his 1869 patent, etc.

The Cinématographe's quality as an invention essentially lies in its eccentric cam, which was round in the original patent of 13 February

10 Charles Francis Jenkins, 'History of the Motion Picture', *Transactions of the Society of Motion Picture Engineers*, October 1920. Reprinted in Raymond Fielding, ed., *A Technological History of Motion Pictures and Television: An Anthology from the Pages of The Journal of the Society of Motion Picture and Television Engineers* (Berkeley, CA: University of California Press, 1967), 3; O.B. Brown, 'Optical Instrument', United States patent no. 93,594, 10 August 1869.

1895 before taking its definitive triangular shape[11] in the first addenda certificate dated 30 March 1895.[12] But this did not mean there were no more difficulties. Even an ardent advocate for the Lumières such as G.-Michel Coissac had to admit that this cam could not be baptized the 'Lumière cam', because it had existed beforehand: 'I note in passing that in a volume entitled *Synthèse cinématique* [*sic*] published in 1877, Mr. Reuleau [*sic*] describes an eccentric cam that was perfectly identical to the cam used by Mr. Lumière in his first cinématographe'.[13] Michel Frizot adds that the Lumières' 'alternating movement frame moved by a cam,' which constitutes 'their principal technical contribution, as is well known,' even 'ornamented the title page' of the French edition of Franz Reuleaux's book *Cinématique*.[14] This triangular cam in a frame also appeared in Charles Laboulaye's *Traité de cinématique* of 1854 (Illus. 29).[15] Louis Lumière himself did not deny this in 1946, when he corrected Sadoul, who had followed tradition by calling this triangular eccentric the 'Trézel cam' when it was, Lumière remarked, the 'Hornblower cam'[16] – it was described under this name, and as being 'very widespread,' in Reuleaux's *Cinématique* (Illus. 30).[17] In 1905, the catalogue of the Conservatoire national des arts et métiers described its item 2601 as a 'triangular eccentric cam mounted outside its camshaft to transmit to a valve of a steam engine an alternating rectilinear movement with pause,' and indicated that it entered its collections in 1840.[18]

Lumière, in fact, did not claim to have invented the cam, but rather to have shifted it, transferred it. The mythology, forged by Auguste Lumière in particular, is well known:

11 Even though Michelle Aubert and Jean-Claude Seguin note that one of the very earliest prototypes of the Cinématographe, using pincers rather than claws to advance the film, was already equipped with a triangular cam. See Michelle Aubert and Jean-Claude Seguin, *La Production cinématographique des frères Lumière* (Paris: BIFI, 1996), 15.

12 Auguste and Louis Lumière, French patent no. 245,032, for a 'device for obtaining and viewing chronophotographic prints'.

13 G.-Michel Coissac, *Histoire du Cinématographe*, 177. The book is in fact titled *Cinématique*; Coissac provides the wrong title.

14 Michel Frizot, 'Comment ça marche: L'algorithme cinématographique', *Cinémathèque* 15 (Spring 1999): 23.

15 Charles Laboulaye, *Traité de cinématique*, § 325, p. 305.

16 In the revised 1948 edition: Georges Sadoul, *Histoire générale du cinéma*, vol. 1, 423.

17 Franz Reuleaux, *Cinématique*, 600.

18 *Catalogue des collections du Conservatoire national des arts et métiers. Premier fascicule: Mécanique*, 8th ed. (Paris: E. Bernard, 1905), 74.

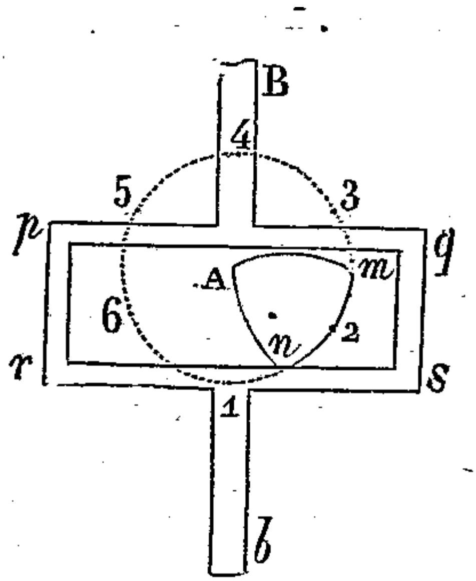


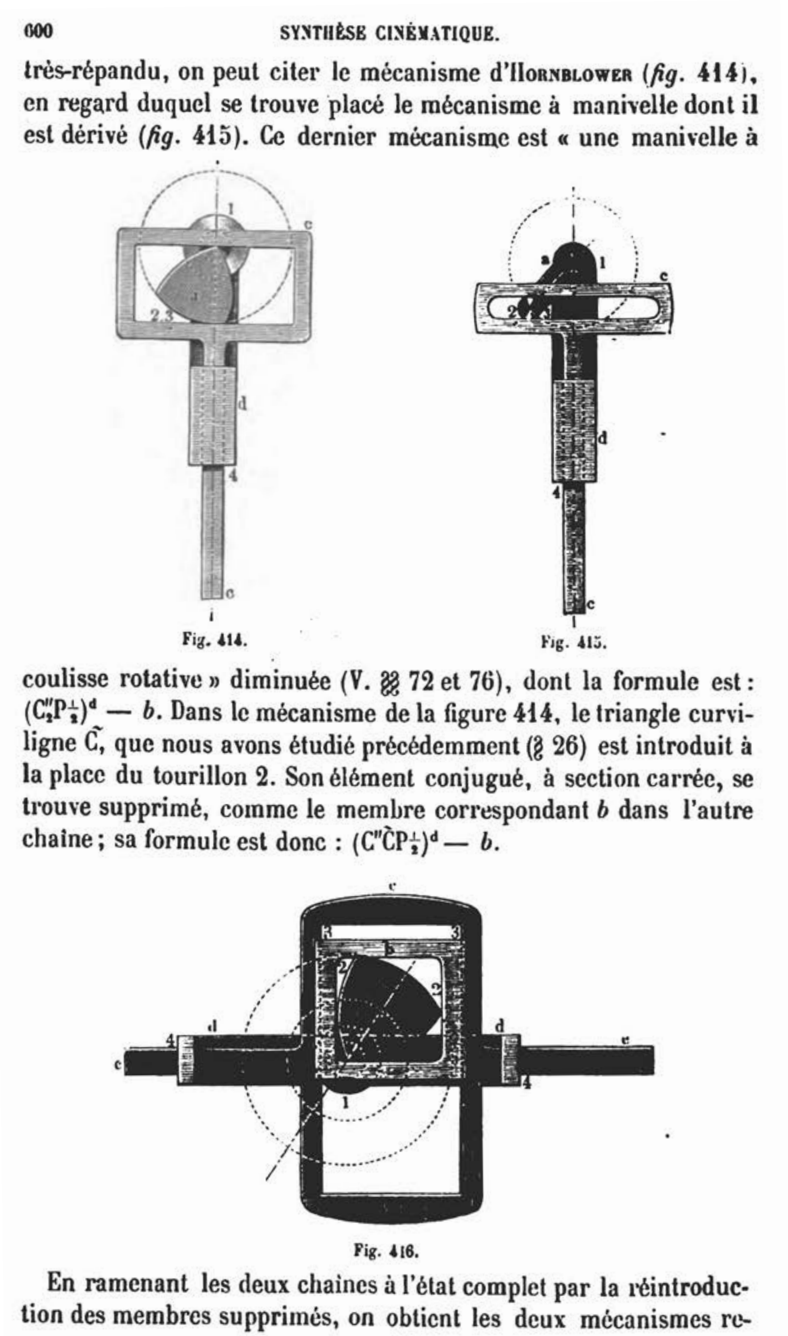
Fig. 284.

Illustration 29 – Triangular cam and its frame, in Laboulaye, Cinématique, 1854.

> First I set out to study the problem by building an initial device which did not fulfil all the conditions that had to be met.
> I was going to undertake the study of a second apparatus when my brother, who had witnessed my initial efforts and lack of success, had the idea of a mechanism with an alternating movement similar to that of a sewing machine. This appeared to constitute the basis for a perfect solution to the question.[19]

Here, we see develop, in a yet another manner, the first stages in the resolution of a problem, posed here by 'Papa Lumière', Antoine.[20] There is a fundamental problem, but also 'conditions' that give it its precise form. And the first, 'abstract' stage is that of the reasoning by analogy and montage described by Bachelard and Simondon. In another version of the story, Auguste is more precise: the mechanism imagined by Louis one sleepless night 'consisted, he told me, of impressing an alternating movement on a claw-holder frame, similar to the way a sewing machine presser foot

19 *Notice sur les titres et travaux scientifiques d'Auguste Lumière* (Lyon: 1940), 12A. Quoted by Jacques Deslandes, *Histoire comparée du cinéma*, vol. 1, 219.
20 Ibid.



600 SYNTHÈSE CINÉMATIQUE.

très-répandu, on peut citer le mécanisme d'Hornblower (*fig.* **414**), en regard duquel se trouve placé le mécanisme à manivelle dont il est dérivé (*fig.* **415**). Ce dernier mécanisme est « une manivelle à

Fig. 414.

Fig. 415.

coulisse rotative » diminuée (V. §§ 72 et 76), dont la formule est : $(C_2''P_2^{\perp})^d - b$. Dans le mécanisme de la figure 414, le triangle curviligne $\tilde{C}$, que nous avons étudié précédemment (§ 26) est introduit à la place du tourillon 2. Son élément conjugué, à section carrée, se trouve supprimé, comme le membre correspondant *b* dans l'autre chaine; sa formule est donc : $(C''\grave{C}P_2^{\perp})^d - b$.

Fig. 416.

En ramenant les deux chaines à l'état complet par la réintroduction des membres supprimés, on obtient les deux mécanismes re-

Illustration 30 – 'Hornblower mechanism'. Reuleaux, Cinématique, 1877.

functions.'[21] Lumière's basic idea was that the 'cinema mechanism' problem was the same as the sewing-machine problem.[22] It was this similarity between the two problems that made it possible to transfer the solutions, by shifting partial *dispositifs* from one domain to another. The coordinated movement of the needle and the fabric in a sewing machine *resembles* that of film behind a lens, enough to imagine that the solution for one would work for the other. These transfer phenomena are systematic and involve crucial epistemological models. One must manage to *see* these resemblances; they must be able to emerge because perceiving and conceptualizing are linked in a way that is part of an entire epistemological system. They outline a network of *dispositifs* without cultural ties but joined by a *kind of movement* seen as similar. The Maltese cross – known also as a Geneva gear in English – comes from clockmaking: it was used in watches to prevent excessive tension in the springs.[23] Regnault attributed perforation to Émile Reynaud. But we have already seen it employed in related fields, in the work of Cros and Ducos du Hauron, in barrel organ music rolls, etc. Michel Frizot remarks that: 'It was hypothesized that perforation may have been borrowed from Émile Reynaud's optical theatre (patented in December 1888), but in fact perforation had been in use for a long time in Wheatstone's telegraph'.[24] For Coissac, it came from ever further away:

> As for perforation, I am looking at a photograph taken from a volume dating from 1840 showing the bands used in jacquard weaving. One sees clearly that these bands have a hole at the edges, exactly like the Cinématographe's film strips. The Lumière brothers, who were constantly exposed to these instruments during their studies at the La Martinière school, had not forgotten this means of advancing the material.[25]

The Cinématographe thus joined sewing and weaving mechanisms to photography. For his Kinesigraph in 1889, William Wordsworth

21 Part of a letter from 1935 by Auguste Lumière 'to the Italian Committee which organized the first fortieth anniversary of cinema events' in Maurice Bessy and Lo Duca, *Louis Lumière inventeur* (Paris: Prisma, 1948), 29.

22 Henry T. Brown, in *Five Hundred and Seven Mechanical Movements* (New York: Brown and Seward, 1896 [1868]), says of this triangular cam that it is 'used in France to work the slide-valve in a steam engine' (p. 39).

23 Charles Francis Jenkins, 'History of the Motion Picture', 4.

24 Michel Frizot, 'Comment ça marche: L'algorithme cinématographique', *Cinémathèque* 15 (Spring 1999): 27.

25 G.-Michel Coissac, *Histoire du cinématographe*, 177-178.

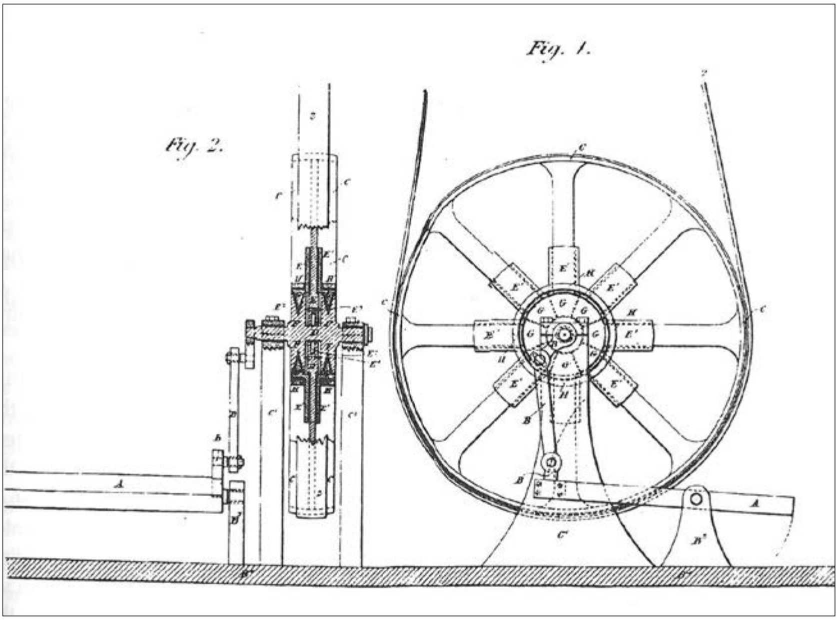


Illustration 31 – Pedal, wheel and pulley-operated advancement mechanism, similar to sewing machines, of W.W. Donisthorpe's Kinesigraph. British patent 12921, 1889.

Donisthorpe had already adopted, for both the camera and the projector, a means of advancement exactly like that of sewing machines of the day: a foot pedal governed a wheel connected to the mechanism by a pulley (Illus. 31).[26] These adoptions and importations of elements belonged to an imaginary of movements that were certainly a part of a cultural dissemination of kinematic science, and enable us to reconstruct something of the epistemological framework in which the '*cinema*' *problem* developed.

In any event, it may seem difficult to situate the precise role, or the place of invention, of the Lumière Cinématographe. As Frizot has remarked, even a 'fairly complex' description of this machine 'nevertheless reveals only a small degree of invention on the part of the Lumière brothers, as most of the procedures involved existed previously. Was the invention due to a technical detail, or merely to the marketing possibilities that would open up to it in a few years?'[27] Yet, as Coissac remarks: 'To the layperson, ignorant of Lumière's work, it appears that everything was prepared for

26 W.W. Donisthorpe and W.C. Croft, British patent no. 12,921, 1889.

27 Michel Frizot, 'Qu'est-ce qu'une invention? (le cinéma): La technique et ses possibles', *Trafic* 50 (Summer 2004): 319.

his invention, that each part of the problem had been solved and that the definitive solution had to have followed easily and logically. Anyone who thinks this way is wrong'.[28]

Any such person is forgetting, on the one hand, that transfers of pre-existing procedures can, in every respect, constitute inventions just as much as the production of new elements. If the Hornblower cam was a solution to the problem, fundamentally rearranging the issues at stake in a new way, then selecting it was an act of invention.

Lumière himself entered into the debate to defend his *invention*. At the time of the supposed thirtieth anniversary of cinema, Paul Noguès presented a note on the 'Invention of the Cinématographe', under the category 'History of the Sciences', to the Académie des sciences at its 8 June 1925 session. In it, he established the objective conditions for the establishment of what in his view characterized the invention:

> The principle of the cinématographe, the essential principle which makes it possible to distinguish it from any other device and any other invention, is the following: *an emulsified flexible film surface is transported with an intermittent and regular movement across the focal area of a lens. A shutter opens when this surface has stopped in order to let light through.*
> This result may be obtained by means of very diverse mechanisms, which may sometimes lead to better and, in their details, new results, such as: improved and more stable projection, projection in three dimensions or in colour, and slow-motion.
> But the first mechanical solution, once it was obtained, was enough to constitute the primary invention, which is to say to determine who invented the cinématographe.[29]

Following a demonstration, Noguès' conclusion was incontrovertible: 'Marey, whose work was the indispensable basis for all moving photography, was both the theorist and the creator (from 1882 to 1890) of the underlying *dispositif* which constitutes what we call today the cinématographe'.[30]

Louis Lumière could not see himself stripped of his title in this way, at the Académie of sciences no less, and replied in person the following week.

28 G.-Michel Coissac, *Histoire du cinématographe*, 167-168.

29 Paul Noguès, 'L'Invention du cinématographe', *Comptes rendus hebdomadaires des séances de l'Académie des sciences* 180 (1925): 1723-1724.

30 Ibid., 1725.

He contested the definition of the cinématographe given by Noguès, 'which corresponds in reality only to analytical chronophotography,'[31] and provided in his defence several quotations from Marey himself, each time referring to the Cinématographe as an *invention* and underscoring the historical importance of the Lumière machine.

In order to discern, finally, whether or not there was an element of invention in the Lumière Cinématographe and to try to describe where any such invention may lie, we must first stop focusing on the cams and perforations alone and examine the machine as a whole (Illus. 32).

On 13 February 1895, Auguste and Louis Lumière filed a patent application (no. 245032) for a 'device for obtaining and viewing choronophotographic prints.' Four addenda certificates were attached to the patent application, filed on 30 March and 6 May 1895 and on 28 March and 18 November 1896. These addenda illustrate how the Lumières' thinking about the machine's technical aspects had continued unabated for almost two years. The title and initial paragraphs clearly establish the framework under which the Lumières conceived their invention:

> It is known that chronophotographic prints give the illusion of movement through the rapid succession before the observer's eyes of a series of photographs, taken at rapid intervals, of objects or people in movement. Our invention consists of a new device for obtaining and viewing these prints.[32]

Two things should be noted here. First, this is at the very least a modest introduction. Beginning a patent application with the words 'it is known that' does not lead one to expect a revolutionary invention. The device is thus presented as a new way of obtaining a familiar effect and not as a procedure for making it possible to obtain a hitherto unseen effect. This would appear to suggest that the status of the Cinématographe was closer to innovation than it was to invention.

The second thing is that it would be impossible to situate the Cinématographe in the conceptual framework constructed by Marey more clearly

31 Louis Lumière, 'À propos de l'invention du Cinématographe', *Comptes rendus hebdomadaires des séances de l'Académie des sciences* 180 (15 June 1925): 1808.

32 Auguste and Louis Lumière, French patent no. 245,032, pp. 3-4. Contrary to a common claim, the name 'Cinématographe' appears neither in the initial patent application, nor in any of its addenda certificates. Lumière employed a capital 'C' in 'Cinématographe', which Noguès omitted.

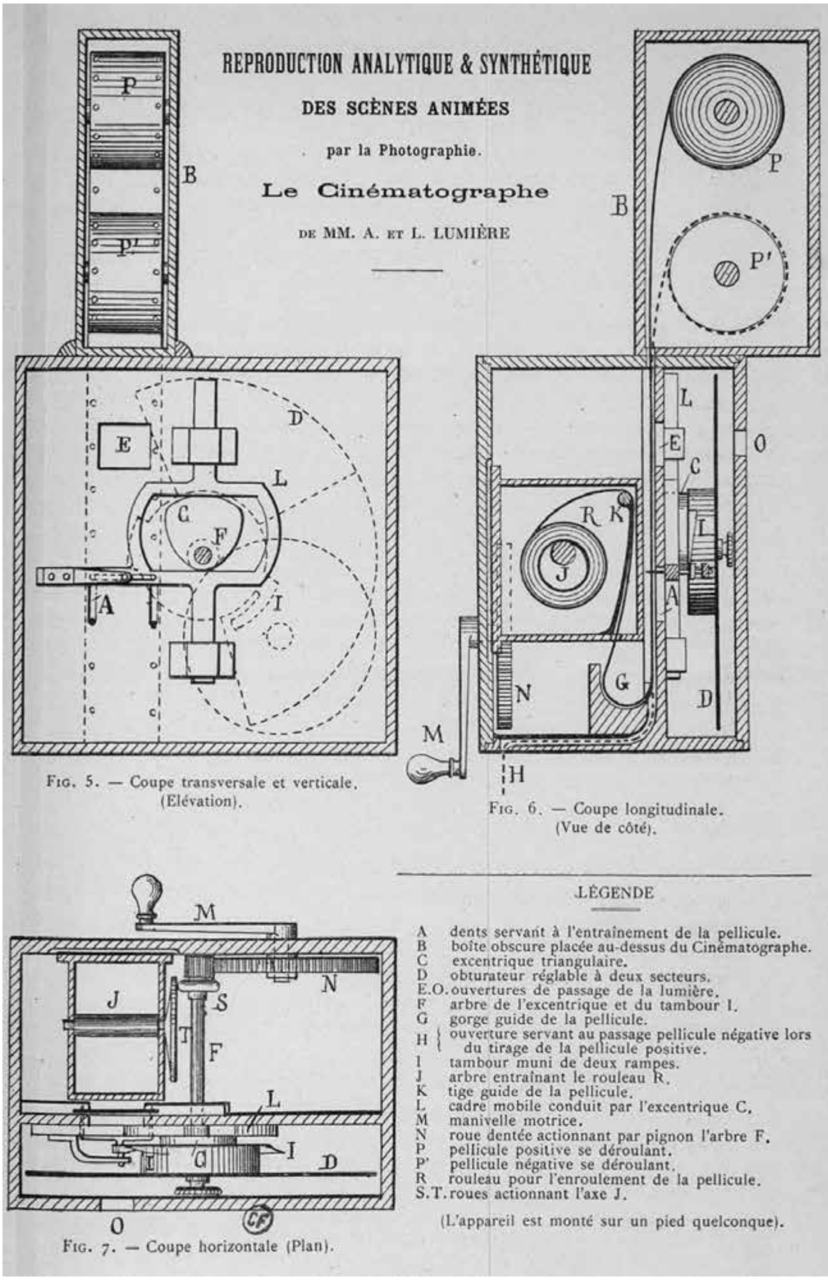


Illustration 32 – Description of the complete Cinématographe by elevation, drawing and cross-section, in Armand Sée, Le Cinématographe de MM. A. et L. Lumière, 1896.

than it is in this opening statement. The Lumière brothers' device was only a new machine for obtaining the 'chronophotographic prints' discovered by the physiologist. What the machine produced was a series of images in no way distinguished in essence, in the patent application itself, from Marey's works – even though there is an element of heresy in stating that 'chronophotographic prints give the illusion of movement,' thereby situating these prints on the side of synthesis and the art of deception. Of course, establishing the new machine's connection to Marey this explicitly was also a way of eluding comparisons between it and a more direct commercial competitor, such as the Edison Kinetoscope.

Nevertheless, an initial specificity is apparent: the singular used for the term 'device' – a sole machine used both to obtain and to view the prints. This defines one of the device's fundamental qualities, already identified as specific to it by historiography: the *reversible* nature of the Lumière Cinématographe. Here, too, attributing this reversibility to the Lumières is complex, because we know that Léon Bouly had already filed a patent application on 27 December 1893 for a 'reversible photographic and optical device for the analysis and synthesis of movements, called the Léon Bouly Cinématographe' (Illus. 33).[33] There is, moreover, a specific history of reversible optical devices based, explicitly or not, on the principle of the reversibility of light. A reader of *The Gentleman's Magazine and Historical Chronicle*, S. Parrat, described in a letter to the magazine dated 30 March 1753 an 'improvement of an optick [*sic*] machine for viewing perspectives in, which is very easily constructed.' This optical box, reduced to the simple form of a lens, a few pieces of wood and a well-placed image base (Illus. 34), had an additional advantage: by replacing the image with a screen and by turning the lens towards an object rather than using it as an eyepiece, then 'you will have a portable Camera Obscura.'[34] A lens makes it possible to view an image under good conditions; it also, inevitably, makes it possible, *by turning it around*, to produce a similar image.

33 Léon Bouly, French patent no. 235,100 (strangely, at the end of the document the machine is called the 'Cynématographe Léon Bouly'). Bouly took out two patents for a 'Cinématographe': the first (no. 219350) was filed on 12 February 1892, three years and a day before the Lumière patent was filed, was for an 'instantaneous photographic device for automatically and without interruption obtaining a series of analytical pictures of movement, or for others called 'the Cinématographe'. This initial device was not reversible.

34 S. Parrat, 'Machine for Perspectives', *The Gentleman's Magazine and Historical Chronicle* 23 (April 1753): 171.

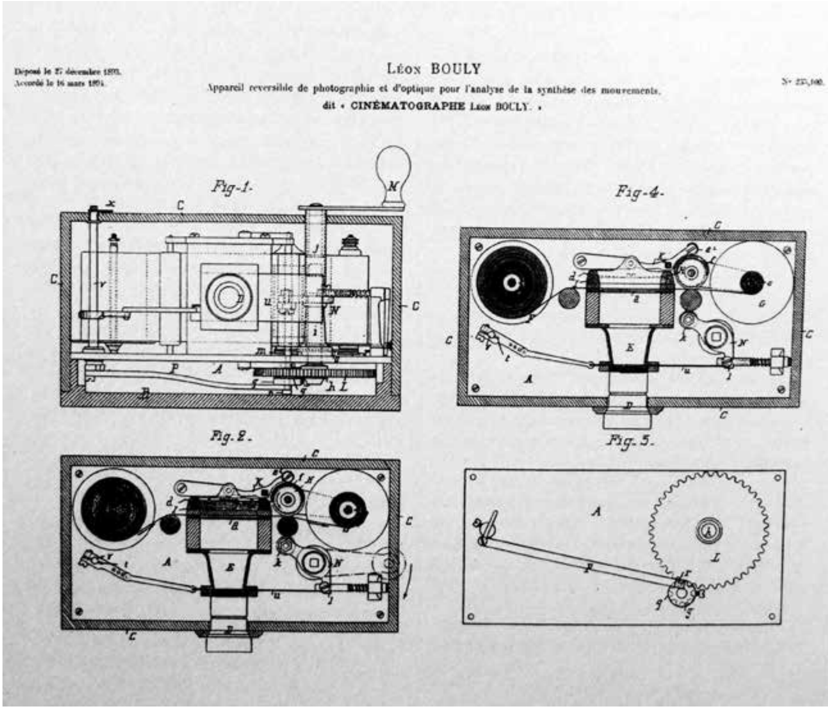


Illustration 33 – Mechanism of the 'Léon Bouly Cinématographe', a reversible device. French patent 235100, 1893.

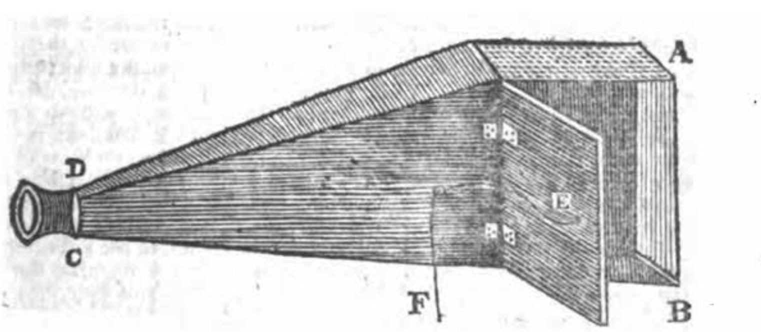


Illustration 34 – Reversible optical box as camera obscura for home construction. S. Parrat, The Gentleman's Magazine, 1753.

Interestingly, the term 'reversibility' does not appear in the Lumière patent application. According to its description, 'the mechanism' can be used 'either in the same device or in different devices':

> 1. To obtain negative images or pictures by directly exposing the scenes to be reproduced
> 2. To print positive prints
> 3. To view moving photographs directly or projected onto a screen.[35]

It was essentially *the same machine*, which would serve to 'expose' the scenes and to view them, to which was added its possible use as a *printer.* This latter aspect, a new element introduced by the Lumières, is often overlooked, because the operation is seen as less important practically and less crucial theoretically than the fine symmetry of taking and projecting pictures. Nevertheless, it was decisive, in that for the Lumières reversibility was connected to the possibility that the machine could be *autonomous*. One should thus be able to go anywhere with a Cinématographe and *have no need of anything else* to produce and show moving photographic images. Nothing else, apart from the ordinary developing and fixing products familiar to any well-versed amateur photographer, along with a good light source for the projection.

Reversibility, for the Lumières, was a primordial element on which the entire conception of the machine was based. Louis Lumière wrote to Georges Demenÿ on 28 March 1895, six days after the first presentation of the device at a lecture for the Société pour l'encouragement à l'industrie:

> At that session I showed a chronophotographic series of eight hundred prints obtained with a new reversible device which we have patented. This device, as I have told you, was already under study when you and I had the pleasure to meet, and I believe it fulfils a different goal than the device you have built to obtain large images in relatively short series. As I also told you, the future lies with these reversible devices, if I may be permitted to put it that way, and to our eyes it is of capital importance.[36]

This was Lumière's victory letter: his device had been patented, the demonstration carried out. Nevertheless, it points out that the *problem* solved by the Cinématographe was not exactly the same as the problem Demenÿ set out to solve. Louis Lumière did not set himself the 'condition' – to adopt the term employed by Auguste – of creating *large* images, because the analytical phase, which was still important in Demenÿ's conceptual framework, was no longer important for him. The reason 'the future lies with these reversible

35 Auguste and Louis Lumière, French patent no. 245,032, p. 8.

36 Letter quoted by Maurice Bessy and Lo Duca, *Louis Lumière inventeur,* 29-30. Reprinted (with a few variations) by Georges Sadoul in *Louis Lumière* (Paris: Seghers, 1964), 9-10.

devices, if I may be permitted to put it that way' is because this stance was in the first place a marketing policy decision.

Our task is to put research on the Cinématographe into the industrial context in which it was carried out. The success of the Société des plaques et papiers photographiques A. Lumière et ses fils at the time was due in particular to the '"blue label" dry plate,' patented in 1883, 'whose qualities were such that it became a great commercial success,' Jacques Deslandes reports.[37] The plate was dry, and thus easy to use. The user did not need to carry around the chemical products required by wet emulsion procedures. It was also quick: the brand's natural 'target audience' was amateur photographers, men and women alike, and its reputation was made on yielding a compromise between a photograph 'on the cutting edge' of instantaneous techniques and an ease of use that guaranteed it would be accessible to the greatest number of people. These criteria were transposed to the Cinématographe. Thus, Louis Lumière could respond in the following manner on 22 October 1895 to a purchase request from H. Mesnier of Bordeaux:

> We have not overlooked your previous request regarding the Cinematograph, but we have not yet settled the price, nor the moment at which we shall put it on sale. As soon as we can, we shall let you know.
> The machine is not complicated; it will be easy to handle and is unlikely to go wrong provided it is in the right hands. No special knowledge will be required for its use; at least, not over and above a knowledge of photographic techniques.[38]

This was the context and public for which the Cinématographe machine was envisioned.[39] The conditions of the Lumière problem were specific in this sense. The autonomy of the device, on account of its (triple) reversibility, guaranteed its possible use by amateurs without any specific infrastructure at their disposal and without having to purchase anything but the machine itself. This meant that the project of marketing the Cinématographe, begun in the spring of 1897, took precedence over the system of shows (paying public screenings) established at the time of the success of the experimental projections in 1895 and in reaction to this stunning triumph.

37 Jacques Deslandes, *Histoire comparée du cinéma*, vol. 1, 219.

38 Auguste and Louis Lumière, *Letters* (1994), ed. Jacques Rittaud-Hutinet, trans. Pierre Hodgson (London: Faber and Faber, 1995), 32.

39 On these points, see Guy Fihman, 'La Stratégie Lumière: L'invention du cinéma comme marché', in Pierre-Jean Benghozi and Christian Delage, eds., *Une histoire économique du cinéma français (1895-1995): Regards croisés franco-américains* (Paris: L'Harmattan, 1997), 35-46.

The Edison System and the Question of Celluloid

The Lumières' project was in radical contrast with that of their sole *industrial* competitor on this point, the Edison Kinetoscope. As we know, Edison's explicit model in designing his system for exhibiting moving photographic images was the phonograph, marketed as an individual peep show in parlours across the country.[40] This model was both economic and conceptual: it involved the technical design of the machines. The first endeavours by W.K.L. Dickson, in charge of the research for the Kinetoscope project at West Orange, recorded the images on a cylindrical base, just like that of the phonograph but which was, as Paul C. Spehr points out, 'completely foreign to photography.'[41] The principle involved the centralized production of software, the recorded cylinders, to be distributed in multiple copies and used numerous times (as each viewing brought in a single penny, their economic feasibility required a great number of viewings).

Edison's system was essentially non-reversible. On the one hand, the Kinetograph – the camera used – was a unique object, not mass produced, handled by a limited number of professional specialists and creating the film strips in a centralized location: the ad hoc studio nicknamed the Black Maria. The Kinetograph was heavy and required a source of electrical energy. It was not intended to be moved, forming part of a technical ensemble which included the studio and its operators. Without these elements it could not carry out its functions, at least in the initial state of the device as conceived by Edison. At the same time, the machines designed solely and specifically for reception, the Kinetoscopes, were constructed in great numbers and distributed on a large scale. They had to be very simple to use; hence they were automated, with an electric motor, and were coin-operated. Their reliance on electricity was not a hindrance, as they were intended to remain in sites designed expressly for them.

This fundamental asymmetry of the Edison system is also found in the technical design of the machines. The Kinetograph is a device with an intermittent advancement of the celluloid strip, a condition seen as necessary. But Edison and Dickson conceived of the Kinetoscope as a machine in which the film advances continuously (Illus. 35). The system derived directly

40 For the engineer Armand Sée, writing in 1896, the *problem* of the phonograph and that of the Cinématographe were similar: 'the recent invention of the Cinématographe by A. and L. Lumière has resolved, with respect to light phenomena, the problem which Edison's phonograph had solved for acoustic phenomena.' See *Reproduction analytique et synthétique des scenes animées par la Photographie: Le Cinématographe de MM. A. et L. Lumière* (Lille: Le Bigot Frères, 1896), 1.

41 Paul C. Spehr, *The Man Who Made Movies: W.K.L. Dickson* (New Barnet: John Libbey, 2008), 90.

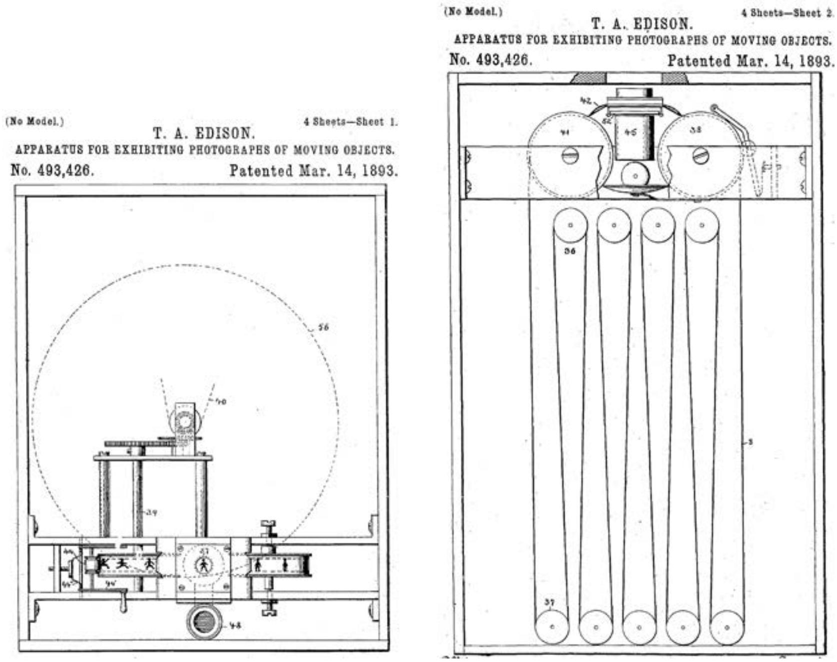


Illustration 35 – Edison Kinetoscope mechanism with uninterrupted movement. Shutter wheel 56, with a very thin slit, covers window 57 for a very limited amount of time. U.S. patent 493426, 1893.

from the zoetrope: A very narrow slot allowed each image to be viewed for a very brief time (about 1/7,000 of a second in theory), a sufficiently short period of time for the strip of film to be perceived as *practically immobile* by the viewer's eye. This required considerable constraints: a relatively high speed (of forty-six images per second in theory, although this speed was probably never used) and as a result a limited length for the scenes depicted (around 30 or 40 seconds) using strips with a maximum length of seventeen metres and a relatively limited exposure time when recording the images.[42] This also meant, in particular, that the images would be dimly lit when viewed, and made it impossible in particular to envision projecting the strips onto a large screen.

Why, then, was continuous advancement of the film strip chosen? The primary *problem* this choice had to resolve, it appears to me, was tied to a material still little known at the time of Dickson's research: celluloid, introduced to the market by the Eastman company in 1888. According to Paul C. Spehr,

42 On these points, see Paul C. Spehr, *The Man Who Made Movies*, 330.

> The trade press of the day was filled with comments about the problems celluloid users encountered, some of which would have been particularly worrisome when filming movement at a rapid rate. There were complaints about [its] stiffness and brittleness [...]. As it dried after developing celluloid curled into a tight roll. This could be controlled by keeping it taut, but this made processing difficult. Among the problems that Dickson encountered were frilling on the edges, cockling and the separation of the emulsion from the base during processing. Eastman was troubled with spots, electrical discharges that showed on the film as lightening-like streaks, emulsions that faded and problems with increasing sensitivity so rapid exposures could be taken.[43]

Celluloid was unstable and fragile, and little was known at the time about its stability and long-term resistance. Yet, the exhibition system of individual viewings required that the strip pass numerous times through the machine if there was to be any hope of making a profit. It was thus logical that the Kinetoscope's specific problem have as its condition that intermittent movement be abandoned, as this would have brought about mechanical constraints on the strip of celluloid that were too great.

The Edison system demonstrates consistency between the conception of the mode of exhibition and the design of the machines. The economic system in which the devices had to operate was part of the specific conditions of the problem that the technical structure had to resolve. The exact *position* of Edison's problem contained the project of making photographic images move, but also the particular environment in which this would take place, this environment's economic and technical conditions. As Guy Fihman remarks, in these inaugural phases of a procedure, 'the device's performances do not determine its market; rather, the target market and marketing methods determine the form of the device.'[44]

For Lumière, the possibility of reversibility lay technically in creating a system of intermittent advancement compatible with its material – the strip of celluloid – and the exhibition system envisioned. Lumière himself explained:

> One of the things that caught my attention was the resistance of film. At the time, film on celluloid was a new product whose features and properties we were not familiar with. So, I set about conducting methodical

43 Ibid., 110.

44 Guy Fihman, 'La Stratégie Lumière', 37.

> experiments, sticking needles of varying diameters through the strips, to which I hung increasing weights.[45]

The mechanism had to be established using weak data on the physical resistance of the base. Projection is inherently less demanding on the strips than individual viewings, as each passage through the machine brought in not just one penny, but rather the pennies of 'an entire assembly.' In any event, it was the imperative that the celluloid not be damaged that determined the mechanism's qualities, and it is for this reason that the system of claws was designed – as described in the patent application:

> Each movement [of the regularly perforated strip] has been recorded, moreover, at varying speeds, beginning and ending at a standstill and at the fastest rate in the middle in order to not damage the strip by grabbing onto it or letting go of it too abruptly.[46]

In this way, 'the points grab onto and let go of the strip with no impact and as a result without damaging the perforations.'[47] Here is where the shape of the perforation comes into play – as well as that of the claws, moreover, which Lumière asked Carpentier to modify again on 15 December 1895.[48] Perforating the film meant weakening it. This is what, for Marey, helped justify his refusal to perforate the film – along with other reasons (the images would be smaller on a base of the same size, and for Marey perforations meant the images would lose stability and fixity[49]), possibly including epistemological considerations.[50] The Skladanowsky brothers, for their part, decided to equip the perforations of films used in their Bioskop with metal eyelets. For the constant advancement of the film in the Kinetoscope, Edison's four rectangular perforations, engaging with a toothed wheel, were a good solution. But the film would be weakened less if it were perforated

45 Quoted by Georges Sadoul, *Louis Lumière*, 15.

46 Auguste and Louis Lumière, French patent no. 245,032, p. 4.

47 Ibid., 6

48 The points should be 'finished with a flat edge about 1.2 millimetres in diameter' rather than being sharp, in order to not damage the film strips, even in the case of slight differences in the proportions of the intervals between perforations. Auguste and Louis Lumière, *Letters*, 72.

49 'If the perforations have imperfections, they produce an annoying shakiness in the projected images; finally, even strips with the best perforations wear out after a period of time; the holes become rough-edged and shakiness in the images results'. Étienne-Jules Marey, quoted by Laurent Mannoni in *Étienne-Jules Marey: La mémoire de l'œil* (Paris: Cinémathèque française, 1999), 348.

50 See Michel Frizot, 'Comment ça marche', 15-27.

just once per image, and a round perforation would be less susceptible to tear or break from the impact, however minimal, of the claws. The Lumière perforations were certainly an economic strategy, making it impossible to run Lumière pictures through a Kinetoscope and vice versa; but they were also a result of thinking about a major technical point: optimizing the mechanical resistance of the strips of celluloid.

Research into celluloid's resistance was thus a condition of the possibility of the viability of a machine designed for the commercial exhibition of moving photographic images, but was especially necessary given the unavoidable need for intermittent movement in a machine envisioned as being reversible, or more generally for an exhibition system based on projection. The claw system, ordered by the triangular cam providing the moment of stoppage (Illus. 36; between positions 1 and 2 the camshaft has turned but the claw frame has not moved) and the immobility of the strip at the moment the points enter the perforations, was determined by this fundamental requirement. In their 1897 *Notice*, the Lumière brothers spoke of this articulation as crucial:

> It will be understood from this the precision that was required in constructing the device so that throughout all of these movements the film strip, although very fragile, would remain completely intact in order to be used a great many times. We achieved this result thanks to the *alternating movement* of the frame under the impetus of a *triangular cam, which was the fundamental object in our patents*. In this way, the claws start and stop at as gradual a speed as possible, and their sinking motion begins *only after the film has come to a complete stop* in order not to damage the holes.[51]

The remarks put in italics by the inventors indicate the structure of causalities that, for them, underlies the machine's internal logic.

Reversibility, Instantaneousness, and Photogram: The Question of the Adjustable Shutter

The fact that it was a commercial arrangement does not prevent reversibility from remaining a part of the conceptual framework developed by

51 Auguste and Louis Lumière, *Notice sur le Cinématographe*, 5. Reprinted in *La Revue du siecle*, 236. Emphasis in the original.

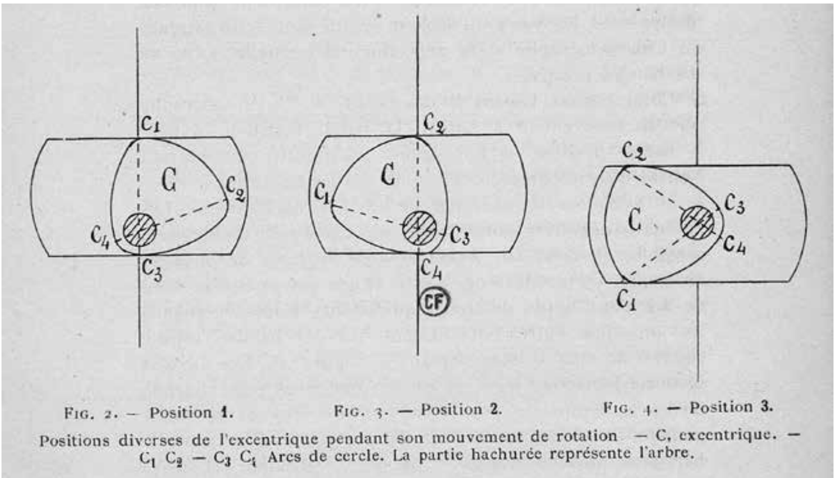


Illustration 36 – Three positions of the cam in its frame. In positions 1 and 2, the camshaft has turned but the frame has not moved. Armand Sée, Le Cinématographe de MM. A. et L. Lumière, 1896.

Étienne-Jules Marey. Although this physiologist had a reputation for not being central to the question of the 'synthesis of broken-down movements,'[52] in 1894 he devoted the final chapter of his summa, *Le Mouvement*, precisely to this question. There, he presented the attempts that had been made to date and closed his book with discussions of 'the conditions a good device must fulfil' and 'an attempt to construct a Chronophotographe projector.'[53] The first of these two parts was essentially devoted to demonstrating the need, in order to project images, for a *dispositif* with intermittent advancement: 'the necessary solution is that which I adopted for the Chronophotographe.' He continued:

> This device, which is used to analyse movements, is reversible, at least in principle, and could be used to reconstitute them. Suppose that a strip of film loaded with positive images passed in front of the lens and that this strip was strongly lit from behind [...]. Every time the shutter opened the lens, an image would appear, and the outline of the image would be perfectly sharp, because at that moment the film would be immobilized by the compressor.[54]

52 On this point, see the work of Maria Tortajada, and in particular 'L'Instantané cinématographique: relire Étienne-Jules Marey', *Cinémas* 21, no. 1 (Fall 2010): 131-152.
53 Étienne-Jules Marey, *Le Mouvement* (Paris: G. Masson, 1894), 317.
54 Ibid., 309.

The stop and go of the intermittent shutter was therefore the same for analysis and for synthesis, and this mechanism could, in theory, be applied to each of the two *dispositifs*. And yet, Marey immediately imposed a major restriction, a crucial one in his conceptual system:

> In a projecting device the illumination should be as long as possible and the transparent plate bearing the images should be stopped for the entire time it will be portrayed on the screen. These, we have seen, are the necessary conditions for very luminous and quite sharp images.
> In the analysing device, on the contrary, the exposure time should be as brief as permitted by the lighting of the object whose images are being taken [...]. But with lighting this brief, an image projected in large dimensions would be invisible, however powerful the light source used to illuminate it.[55]

Thus, while the kinematic principle is identical for analysis and synthesis, the length of time the lens is open – the exposure time or illumination time – is not the same. One cannot obtain a sharp image of a moving object with a long exposure time; this exposure should be *as brief as possible*. And sharpness is an absolutely crucial quality of the chronophotographic image, because it must be able to be used for detailed examination. Chronophotography essentially requires instantaneousness, meaning that the exposure time of the photographic image could be seen as nil or negligible with respect to the time it takes for the movement being analysed to unfold.

This dialectic constituted another *problem* for Lumière, and the solution he proposed raised an important point, although it is never mentioned in the historiography around the Cinématographe: the *adjustable shutter* (Illus. 37). The patent application describes it in the following manner: 'The notch in the disk corresponds to a part of an angle which need only be varied to modify the exposure time and which can reach around 170°, which would be too long to obtain sharp images but which is a very favourable state for viewing images'.[56]

The Cinématographe was a device in the Marey mould, an off-shoot of the Chronophotographe, a response on the part of the Lyon industrial family the Lumières to the challenges issued – and the *problems posed* – by the Parisian scientist. The longest possible illumination time was required

55 Ibid., 309-310.

56 Auguste and Louis Lumière, French patent no. 245,032, p. 7.

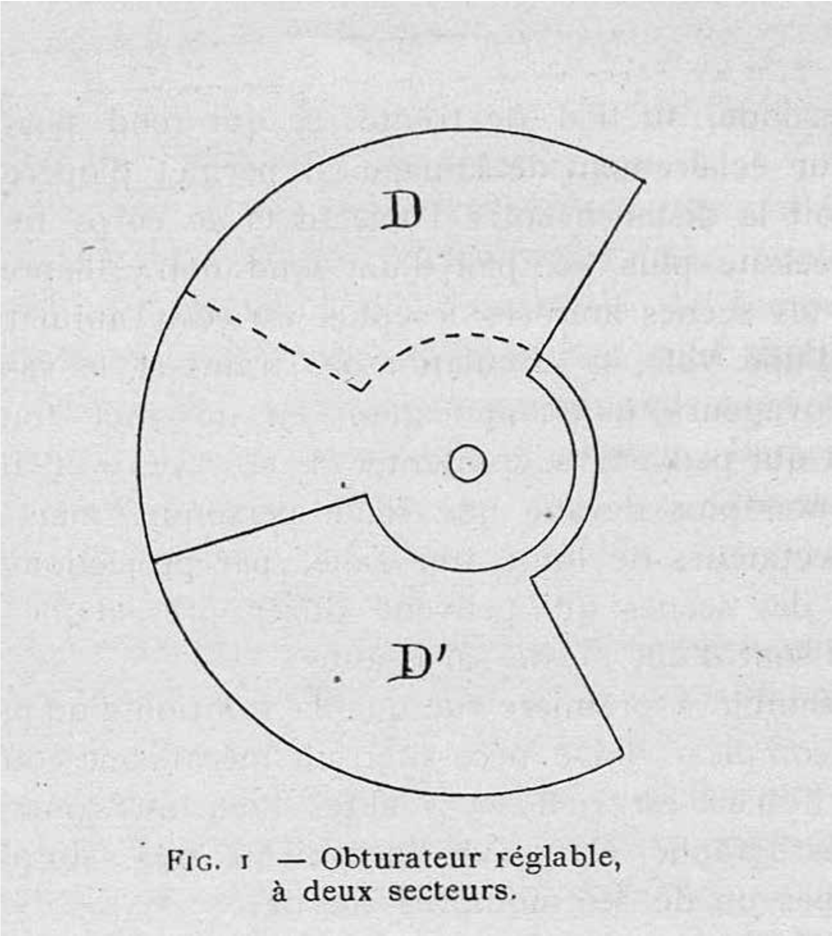


Illustration 37 – The Cinématographe's superimposed dual-blade adjustable shutter.
Armand Sée, Le Cinématographe de MM. A. et L. Lumière, 1896.

to ensure good projection, so one installs a shutter that will open as much as possible. Then, one needs a mechanism capable of pulling the film down in as little time as possible in order to leave it immobile as long as possible. This was the role of the triangular cam, which has the ability to maximize the length of time the film is immobile compared to the time it is moving. And this must be done suddenly, without, however, mistreating the film.

At the same time, however, the images obtained must be sharp and the shutter must be as narrow as possible when taking the image – with a 180° shutter, a speed of sixteen frames per second would produce an exposure time of 1/32 of a second, which is much too long from the perspective of anyone used to working with the exposure times in the Marey tradition.[57] The shutter, therefore, had to be adjustable: the angle would be changed between the configuration of the Cinématographe to obtain negatives and the configuration for projection.

But Jules Carpentier, tasked by the Lumières with the definitive fine-tuning of the Cinématographe and its mass production, was not convinced by this adjustable shutter. On 4 November 1895 he wrote to Louis Lumière:

> Machine no. 1 has had the largest number of improvements. You will discover that it now contains a shutter consisting of two thin blades (metal) which permits variations in aperture and, consequently, in exposure [...]. This mechanism is not very convenient for the man in the street and if we decide to provide all the machines with variable aperture, we should have to do better [...] but is it necessary? One element is bound to remain unpredictable and that is the speed at which the camera is cranked.[58]

For Carpentier, the adjustable shutter was a pointless complication of the machine, 'a mechanism which can only make it more expensive,'[59] but which also makes it more fragile, and could cause problems for its users with only negligible benefits given the overall design. Lumière refused to discuss the necessity for this element, but the argument no longer centred directly on the question of image sharpness. Because one had to be able to vary the exposure time without changing the film speed, otherwise

> that would mean shooting shorter scenes in fine weather and longer ones on cloudy days. When the film is projected, either the characters would move too slowly or there will be a waste of film because the elementary images will appear on the screen with an unnecessary speed of more than fifteen frames per second.[60]

In fact, the lens was not equipped with a diaphragm and the exposure time could only be regulated by the rate at which the film advanced; it

57 We might note here that amateur photography manuals advised an exposure time less than or equal to one sixtieth of a second. A longer exposure brought the risk of 'blur from movement' in the image, meaning blur caused not by the movement of the objects photographed (this could be sought for aesthetic reasons) but by the failure to keep the camera completely immobile during exposure (this could be seen as a 'defect'). It was advised, therefore, to place the device on a tripod.

58 Auguste and Louis Lumière, *Letters*, 36-37.

59 Ibid., 41. (Translation modified – Trans.)

60 Ibid., 38. (Translation modified – Trans.)

was therefore necessary to regulate the shutter. Discussions between Carpentier and Lumière continued regarding the material and exact shape of this shutter: the vulcanite initially spoken highly of by Carpentier, for example, turned out not to resist the heat of the projection lamps. On 22 December 1895, he announced that he had destroyed all the vulcanite shutters that had already been produced in order to redo them 'in thin, blackened brass. Fibre is useless. The new shutters will naturally be more solid. They will also be heavier, which may not be a drawback.'[61]

More than a month later, however, on 6 February 1896, Louis Lumière changed his mind and gave up on the adjustable shutter:

> I have remarked that the shutter should be left open as wide as possible when obtaining the negatives: this prevents a jumpy effect when representing sudden movement. We should therefore not hesitate to allow only a fixed shutter disc, giving an invariable setting. The exposure time can be varied according to the lens diaphragm. We need to be able to operate at approximately f/12.5, f/18 and f/22.[62]

This was a major and crucial reversal. Lumière had 'remarked', by experimenting with his machine and watching pictures on it, that the position in which the shutter was open as much as possible was not only best suited to projection, but *also* to 'obtaining negatives.' And this was not due to the fact that the sensitivity of film emulsions, which was very low by today's standards, required the maximum possible illumination of the film strip, because Lumière asked that a diaphragm be installed to close the lens in order to compensate for opening the angle of the shutter. Rather, his reasoning had to do with Marey's criterion concerning the sharpness of the images. What Lumière observed was that an 'elementary image', a cinema photogram, can be *too* sharp. If the filmed movement was too 'abrupt', a series of perfectly sharp images, obtained like chronophotographs, i.e. instantaneously, would give rise to the sensation in the viewer of seeing a succession of disjointed and discontinuous images. One would see 'jerking'. Marey and photographers practising *instantaneous* photography detested the blur produced by objects in movement, but with the Cinématographe this blur was a *good* blur.

61 Ibid., 76-77.
62 Ibid., 115.

It was thus only in February 1896 that Lumière became aware of a profound rupture with Marey's epistemological framework, a rupture that, nevertheless, left its mark on the very structure of his machine. An 'elementary image' of the film strip, which today we call a photogram or a film frame, *was not in essence an instantaneous photograph*.

The adjustable shutter adapted to a reversible machine was a transition phase, an 'abstraction residue' Simondon would say, which creates the trace of a profound epistemological rupture brought about by the Cinématographe, one its inventors were not yet aware of at the moment it was developed. The Cinématographe was entirely conceived within the conceptual framework constructed by Marey, but ultimately it escaped it. And this escape was not from synthesis itself, which was still conceived in Marey's terms in the mid-1890s: it was from the nature and function of the instantaneous in the 'cinema' problem.

In this way, a technical and commercial decision, the reversibility of the Cinématographe machine, brought about a series of effects, an epistemological shift. From this point of view, we can state that the true *invention* of the Lumière Cinématographe in fact took place on 6 February 1896, the date when the Marey-like machine with an adjustable shutter became *something else*.

A Concrete Machine

The Lumière Cinématographe was, according to Guy Fihman, a 'unique multi-functional machine (carrying out recording, printing and projection).'[63] It was designed to be mass produced: the manufacture of two hundred devices by Carpentier was already planned as early as November 1895.[64] It was sturdy and easy to use. All these aspects identify it, as Fihman remarks, as a technical object that is exemplarily *concrete*, in Simondon's sense of the term: it was 'much more concrete than the Edison pair Kinetograph-Kinetoscope.'[65] For Simondon, the process by which something becomes concrete was characterized by the fact that 'each structural element fulfils several functions rather than a single one.'[66] The reason a motor 'with a magnetic fly-wheel and which is air cooled is more concrete than a typical

63 Guy Fihman, 'La Stratégie Lumière', 36.

64 Auguste and Louis Lumière, *Letters*, 53.

65 Guy Fihman, 'La Stratégie Lumière', 36.

66 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, 36.

car engine' is because 'each [part] plays several roles.'[67] In this case, not only did the Cinématographe machine as a whole play several roles, dividing up the functions of its elements in varying ways according to how the machine as a whole was being used, but in addition, the structure itself was based on the multifunctional nature of its mechanisms. Thus, the patent application of 13 February 1895 concluded with an intellectual property claim for a multifunctional element: 'A mechanism made up of a single camshaft connected to the occluding disk and the eccentric, cam or crank, designed to give the points a come and go movement and the cam designed to lift these same points during its movement while the strip is at rest'.[68]

Because the movements of the claws, the film, and the shutter had to be rigorously synchronized, a single camshaft, constantly kept in motion by the operator through the crank, was responsible for the entire process of driving the film.

The fact that the Cinématographe was conceived as a device to be mass produced is not a neutral point here. As Simondon remarked, 'artisanal production corresponds to the primitive stage of the evolution of technical objects, i.e. to the abstract stage; industry corresponds to the concrete stage.'[69] The 'abstract analytical order,' the first stage of the technical object, gives way to the 'synthetic [organizational] order' characterizing the stage of becoming concrete through a 'passage from artisanal production to industrial production'; 'at the industrial stage, the object has achieved its coherence.'[70]

The demands of industrial production require consideration of the machine's internal cohesion, its efficient minimal form. On 9 November 1895, Jules Carpentier wrote to Louis Lumière: 'The assembly line, however, has taught us that certain details will, in the future, need rethinking'.[71] The exchange between Carpentier, 'the best manufacturer of precision instruments at the time,'[72] tasked precisely with the Cinématographe's mass production, and Lumière, a novice in this field, constitutes a true process of technical thinking whose direction was making the machine concrete. It put into play thinking not only about the mechanism, but also, crucially, constant interaction with use. Every modification made by Carpentier was immediately tested by Lumière by putting the machine into operation and

67 Ibid., 31.

68 Auguste and Louis Lumière, French patent 245,032, p. 12.

69 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, 28.

70 Ibid., 31-32.

71 Auguste and Louis Lumière, *Letters*, 41.

72 Guy Fihman, 'La Stratégie Lumière', 36.

by recording and viewing a strip of film. Consequently, use did not come after designing the machine; it was immediately integrated into it. These exchanges addressed the shutter, the need for it, and its composition, but also, for example, the glass pressure plate, which pressed the film against the exposure window while it was stopped behind the lens. This mechanism was of critical importance and posed numerous technical problems – 'it is relatively difficult and slow to assemble,' Carpentier wrote that same 9 November.[73] The pressure had to be fairly firm to ensure the fixity of the image. If it were too tight, however, it would constrain the celluloid and perhaps also the user. In addition, Carpentier remarked, 'it will have its edges rounded off and it will be polished up to optical standards,'[74] because the least snag would scratch every film strip passed through the machine. But Lumière had to ask Carpentier on 23 December 1895 to rework this point, for a specific reason:

> Had the glass pressure plate of machine no. 1 been altered, in relation to the rounding off of the edge? If the answer is yes, then I would ask you to whittle this edge down still further because, through it works very well with new film strips, the same is not true when the strips have been repaired. Obviously, such mending is occasional, but it does allow use of some film damaged by clumsiness.[75]

This 'mending' – the first form of 'editing' or 'abutting', to employ the vocabulary proposed by André Gaudreault[76] – was taken into account by Lumière in the context of making the Cinématographe machine.

Carpentier also gave thought to the machine's use and coherence for the user. For example, he made the decision to have the film magazines produced in greater quantities than the devices themselves: 'The single magazine goes with a metal bin into which the film reels; each machine will obviously need several such pairs of these accessories, so that a cameraman can make several films without rushing to a laboratory in between'.[77]

This was not without commercial consequences, however, because 'the metal bin into which the film spools, though cute, costs us a pretty sum,' adding: 'Consequently, the cost of a pair of spare magazines is forced up,

73 Auguste and Louis Lumière, *Letters*, 41.
74 Ibid., 63.
75 Ibid., 78-79. (Translation modified – Trans.)
76 See André Gaudreault (with Jean-Marc Lamotte), 'Fragmentation and Segmentation in the Lumière "Animated Views"', trans. Timothy Barnard, *The Moving Image* (Spring 2003): 110-131.
77 Auguste and Louis Lumière, *Letters*, 37.

and that will hinder sales of those accessories which, I am convinced, are essential. It is imperative that we manage to simplify'.[78]

To simplify is to recognize the 'primary need' and to organize the machine in such a way for mass production to lower the costs of production – it was a way of making it concrete. A technical object, even a 'cute' one, is not complete – is not *concrete* – if its coherence is not ensured according to its minimal form – a coherence that is mechanical but also inextricably linked to use. A Cinématographe is not a coherent machine if its operator cannot load several strips of film in a row; he must have several magazines available.

The Lumière device, in its form and structure, grew out of a complex and collective process of technical elaboration, bringing together a mechanical idea based on an understanding of the exact nature of the movement to be created and a range of capacities also tied to the mechanism, but in addition to how the machine's designers envisaged its use, its commercialization, and its concrete handling – to their explicit or implicit conceptions of what the machine should be, should do, and the way it should be possible to achieve this.

As a machine, the Cinématographe cannot be understood solely in light of its general task, to obtain and project moving photographic images. Neither the viewer's, nor the operator's point of view enabled them to grasp completely the distinctions between machines, even though the technical, plastic, and aesthetic qualities of the films produced were entirely the product of the success and status of the machine. In Simondon's vocabulary, the user's point of view defines what he calls 'technical kinds':

> It is difficult to define the genesis of each technical object, since the individuality of technical objects is modified throughout the course of this genesis; technical objects are not easily defined by attribution to a technical kind; it is easy to summarily distinguish kinds according to practical usage, as long as one accepts grasping the technical object according to its practical end; however, this is an illusory specificity, because no fixed structure corresponds to a definite usage. The same result may be obtained from very different functionalities and structures [...]. That to which one thereby gives a single name – for instance the engine – can thus be multiple in one instance and may vary in time by changing its individuality.[79]

78 Ibid., 42.
79 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, 25.

The specifying determination of the machine in its own 'individuation' involves taking into account its internal organization, its structure, and the arrangement between this structure and use. Cinématographe cameras and projectors were a technical species, but within this species each object was individuated. The line making up the species has a general problem in common, to which it forms a series of solutions with variants of differing degrees of importance. From this perspective, every individual is the solution to a singular problem, a problem whose position engages both explicit aspects for the inventor and user (the decision to make the machine reversible) and unformulated aspects, 'implicit conceptual structures' that make up the machine's precise epistemological framework. The machine can go beyond the intentions of its inventor; in fact, this is inevitable: 'the technical object is never fully known; for this very reason, it is never completely concrete, unless it happens through a rare chance occurrence.'[80] As we have seen, it was the Cinématographe that led Lumière to reconsider the status of the elementary image, as *experimenting with the machine once it was produced* made him realize the difference between a cinematic 'elementary image' and an instantaneous picture in Marey's sense of the term.

In its real individuality, the technical object can only be understood, and the measure of its contribution or difference, its degree of innovation, can only be measured, by taking the internal organization of the machine into account. Recall that for Gilbert Simondon the evolution of technical objects is set in motion in a dialectic distinguishing two complementary moments: 'relational progress' affecting the interactions between machine, the milieu, and the operator, which is achieved 'by trial and error through use'; and 'internal self-correlation' progress and progress in the structural mode of organization, which 'require a resolution of the problem, an invention.'[81] The former produces 'gradual and continuous improvements.'[82] But the latter is of a different order. Even though it may itself 'be led by the need for relational progress,' it 're-engenders the system's internal logic' and thus supposes or creates discontinuity: 'for this reason, internal technical progress can hardly be continuous; it takes place through leaps, through discontinuous stages.'[83]

I have already quoted what Eugène Trutat wrote about the Cinématographe: '[The Cinématographe's] mechanisms were completely different

80 Ibid., 39.
81 Gilbert Simondon, *L'Invention dans les techniques*, 102.
82 Ibid.
83 Ibid., 103.

from those of the Kinetoscope, and for the most part also different from Mr. Marey's Chronophotographe. But on the whole it was still just a modification of the earlier invention'.[84]

For Trutat, what was invented were the fundamental uses, even if they were organized differently and brought about by a different internal mechanism – but what is the importance in the end, for the historian or the viewer, of a mechanism one does not touch, see, or understand? For Simondon, the difference of mechanisms, their complete re-arrangement, is precisely what lies at the root of discontinuity and invention. In the Cinématographe, the internal re-arrangement meant, for example, in addition to what I have already spoken of here, that this machine was the only one among its rivals in this constellation for which the film strip was *by default immobile*. In the Chronophotographe, the Kinetoscope, and the Kinetograph, in Bouly's Cinématographe, etc., the strip of film was *by default moving*, always being led forward, and the mechanism forced it to stop intermittently. The Cinématographe's claw system operated in reverse: the strip of film was *by default at rest*, with the mechanism episodically printing a brief movement on it. The logic was thus completely different with respect to the central question of intermittence.

There was therefore truly invention at play in the Cinématographe, and not merely an innovation that added projection to the Kinetoscope, or by commercializing a particular form of the Chronophotographe. This invention consisted, through the creation of a singular individual technique, of resolving a problem posed precisely in terms inseparably technical, commercial, epistemological, and even aesthetic, because it was also on the basis of his work as a photographer that Louis Lumière was able to conceive his machine.

This technical invention, as can be seen through an examination of the machine and its genesis, was remarkably 'concrete', joining mass production, multi-functionality, the manufacturing quality of the rendering device and simplicity of use (lightweight, easy to handle), appearance, and internal organization. This quality of simplicity has always been underscored and valorized in the historiography, and not without reason. The role of the Cinématographe in the history of film history can be understood on the basis of this fact: the Cinématographe, through its overall structure and its uses and productions alike, seemed at the time to be *the solution to the problem*. It was the clear and simple solution spoken of by Bachelard, the solution that made it possible to understand the problem itself, precisely

84 Eugène Trutat, *La Photographie animée*, 60.

because it was the concrete machine whose internal arrangement and form demonstrated and clarified the questions' hierarchy and interdependence.

This is why the internal structure of the machine is, in fact, not indifferent to the historian and to historiography, to the technician, or the sociologist. It may seem not to concern the user, but it exists as the very demonstration of the problem, its coherence, and the tools necessary to its resolution. It was out of the Cinématographe that retrospective representations were constructed distinguishing between 'good' precursors and those who got lost in incomprehensible errors (Ducos du Hauron, for example) and between 'good' principles (the flexible transparent film strip, intermittence, etc.) and 'mistakes' (the attempts to create moving images using discs, for example). The Cinématographe's contribution was thus technical and commercial, but its pivotal role in historiography can only be accounted for by the fact that its function was, primarily, epistemological: it was through it that the *'cinema' problem* could be clearly understood, explained, and conveyed.

It is within this framework that we can grasp the insistence of historiography on the reversibility of the Lumière machine. On this topic, in 1946, Jean Vivié noted a kind of paradox:

> A curious fact: [...] although the Cinématographe was born of the idea of applying the reversibility of the recording device for projection, in less than two years – and quite correctly, moreover – industrialization carried out a reversal of the principle, one which has continued into our own day: the recording device would retain the system of driving the film through a claw mechanism so perfectly carried out with the Cinématographe, but a different kind of device would later be used for projection.[85]

In fact, reversibility was quickly abandoned. The logic of paying public shows reintroduced into the projection system established by the Lumières the dissymmetry of the Edison system. The production of pictures was thus centralized and professionalized, while their exhibition was disseminated in venues that would adapt to them in different ways. This production/dissemination dichotomy was not inherent to the Cinématographe machine: it was so in the Edison machines. While projection was a Lumière contribution, the logic of moving pictures as a show and of the manner in which the machines were commercialized and distributed was an invention of Edison's, and this conception would become dominant. The Lumières themselves

85 Jean Vivié, *Traité général de technique du cinéma*, vol. 1, *Historique et développement de la technique cinématographique* (Paris: B.P.I., 1946), 48.

enshrined this dissymmetry, which was their ambiguity, when they produced a special Cinématographe for projection as early as 1897. Afterwards, the forms of the machines and their internal mechanisms became distinct, each evolving according to its own logic. Projectors became heavier and adopted the Maltese cross method of advancing the film, while cameras preserved the claw mechanism.

Reversibility, therefore, played no noteworthy role in the evolution of Cinématographe machines. Its importance in discourses, on the other hand, signals its function as an epistemological *crux*, as a point of crystallization through which the highly concrete nature of the object establishes it as a clear arrangement of the parts of the solution. On the basis of this crux, the historical dialectic, described by Simondon, of differentiation and concretization, of more specialized new machines appearing through adaptation to different or more limited tasks, could play out. These machines would become concrete all over again before dividing up once more.

While a summary topology of machines could seem to distinguish a surface/interface, the place of interaction with the operator and an interior to which he would be indifferent, the real historical function of a machine, even in its social, aesthetic, political, and economic dimensions, can put the internal mechanics into play in a central manner for both epistemological as well as technical reasons.

Other Aspects of the Cinématographe

The Crank (The Operator's Body Part Two: The Hand)

Apart from the question of the invention as it is posed in the historiography, it is interesting to note that other technical aspects of the Cinématographe, even though it is undoubtedly the most commented-on machine in film history, have never been discussed, even at the time. But these aspects are not neutral and their presence and form are not without interest, in that they partially determined the use of the machine, but also in that they situated it in a constellation of practices of the time, which it can retrospectively document and *archive*.

For example, the Cinématographe was a hand-cranked machine. This is consistent with the Lumières' desire to create an autonomous machine that could be used in every setting, and thus independent of sources of electricity, which were rare at the time. This also places it in a lineage of countless machines – viewing and listening *dispositifs*, but also a variety of devices:

coffee grinders; hydraulic systems; some kinds of time-keeping devices; the earliest means to start an automobile, etc. A history of hand-cranked optical devices would include nineteenth-century toys, even if certain distinctions have to be made, because they were unequally equipped.

Only very rarely were either the Phenakisticope or the zoetrope equipped with cranks, but other devices were systematically equipped with them, as were 'loving picture' plates, which were quite popular in the mid-nineteenth century, when the use of cranks made it possible to develop abstract coloured rosettes or to put a particular part of the image in motion. A remarkable example of an optical machine with a crank was John Arthur Roebuck Rudge's magic lantern, built around 1882 (Illus. 38). Here, the crank changed the picture using a shutter system made up of one of the triangular cams with which we are now familiar – even though the cam had no frame and did not serve to transform a continuous rotary movement into an alternating linear movement. In any event, the Lumière Cinématographe was not the first machine for projecting moving imaged to change pictures using a triangular cam. It is interesting to note that when Will Day had a copy of Rudge's lantern made in 1922 (and preserved at the Cinémathèque française), the only liberty he took with the original was to move the crank from its original position in front of the lens to a lateral position – one certainly more practical, in his view, and similar to the position film projectors of the day had adopted. In this case, there was a sort of retrospective transfer, as Day reconfigured the lantern in keeping with the logic and form of a later machine but with which it was retroactively confused.

We might also think of a fascinating machine, but one largely overlooked by history: the Anorthoscope, the first viewing device invented by Joseph Plateau, *before* the Phenakisticope. It used the combined movement of a slotted black disc turning in one direction and, behind it, turning in the other direction, a disc bearing an anamorphic image; by viewing the anamorphosis behind the first disc, the image was made whole. This machine was mostly operated by crank, because the two discs had to be turned together at a matching speed. It is enthralling, moreover, to observe that Plateau, in his instructions for the use of the machine, specified that the person turning the crank should not be the same as the person observing the phenomenon.[86] Viewing is hard work, and one could not do two things at once if in the necessary serious frame of mind.

86 See Maurice Dorikens, ed., *Joseph Plateau 1801-1883: Leven tussen Kunst en Wetenschap, Vivre entre l'art et la science, Living between Art and Science* (Gent: Provincie Oost-Vlaaanderen, 2001).

Illustration 38 – Magic lantern, John Arthur Roebuck Rudge, around 1882 (Cinémathèque française collection).

At the same time, Plateau was interested not only in optics, but also, among other things, in hydrostatics. In this field he carried out an eponymous experiment, based on a machine he had made that operated through the action of a rotating hand-cranked axis (Illus. 39). Under the action of the experimenter/viewer, the shape of a sphere of oil suspended in the aqueous

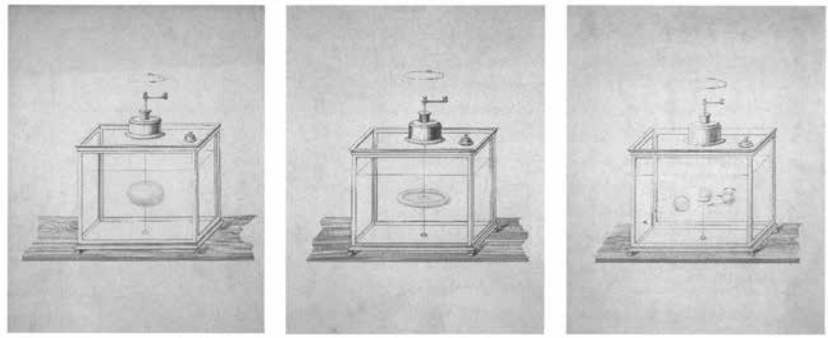


Illustration 39 – Plateau's experiment (from Maurice Dorikens).

solution was transformed according to the speed the crank was turned.[87] The attention paid to the question of the crank gives 'Plateau's machine' a new-found place among nineteenth-century viewing *dispositifs* – a well-deserved place given that it was relatively commonplace, particularly in schools, until the first quarter of the twentieth century. The reason the experiment was enjoyable was certainly because of its visual and simple nature. And yet, this machine is completely absent from the historiography of these *dispositifs*, which is overwhelmingly carried out from the perspective of 'pre-cinema' – because the form of movement created here, by suspended spheres, is radically different from the medium yet to come. There were no two-dimensional images, no analytical deconstruction/reconstruction, etc. This, moreover, is where its interest lies today, from the perspective of an archaeological reconsideration of the machines that lie outside any teleological linearity.

In fact, there had been hand-cranked viewing machines for a long time before then. They can be found in Athanasius Kircher's *Ars Magna Lucis et Umbrae*, beginning with the first edition of 1646: the 'metamorphosis machine', for example, whose crank actions a series of images arranged on a vertical drum (Illus. 40). It is certain that not all of Kircher's machines came into concrete existence, but from our point of view that is only of relative importance: it is enough that this machine was *imagined* with a crank.

Cranks could play several possible roles, sometimes simultaneously, and their form could vary depending on the role. They were necessary when one had to drive several elements at the same time, as with the Anorthoscope, and sometimes heavy elements, as with Rudge's lantern. Or when elements had to be driven to places inaccessible to the hands, as with certain moving

87 Ibid., 100ff.

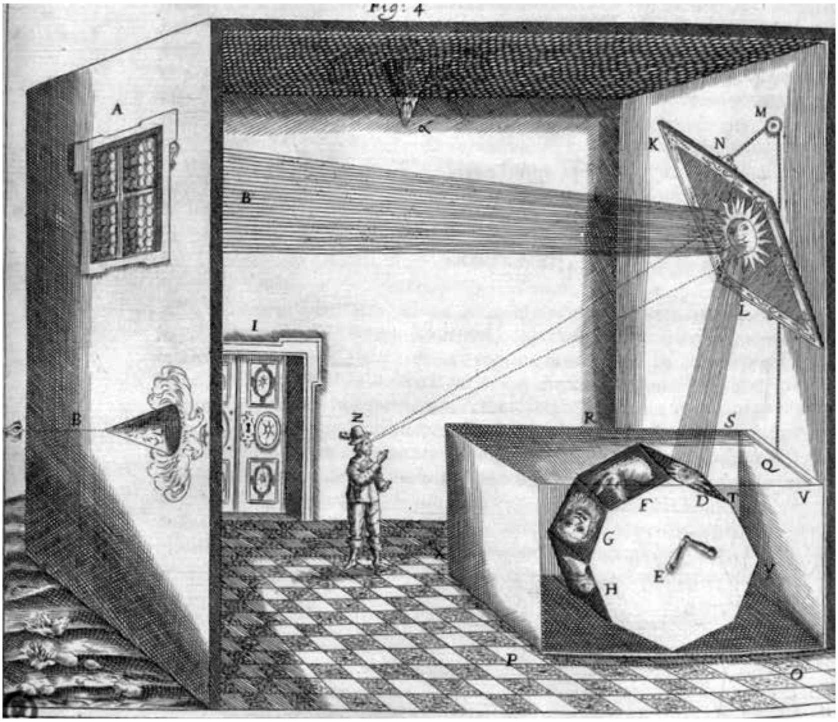


Illustration 40 – Athanase Kircher's transformation machine. The drum uses a crank to advance a series of images pas the mirror. Ars magna lucis et umbrae, 1646.

picture lanterns or plates; or when one had to produce a very rapid movement, as with Isaac Newton's devices for his colour experiments, which required the disc with coloured areas to turn very quickly to produce the effect, so that they were equipped with cranks, pulleys, and belts. Another possible role for a crank is to control the movement.

In fact, the presence of a crank completely transforms one's relations with the machine. In the absence of a crank, the user/viewer, once the disc or the strip is set up, sets the machine in motion and possibly keeps it going or stops it.[88] Between these occasional interventions one is entirely occupied with observing. Nevertheless, it is physically impossible to give the machine a constant speed; it rotates solely through the inertia of the

88 In a very interesting manner, Werner Nekes, demonstrating the Praxinoscope in *Was geschah wirklich zwischen den Bildern?* (West Germany, 1986), the first film in his series *Media Magica*, shows not only the strips moving but the entire assembly of the toy, from the opening of the box, the positioning of the candle, etc., until the appearance of the moving images in the end. This entire *assembly* (*montage*; here the word has echoes) of the machine should be seen as part of the *dispositif* – of the pleasure to which it gives rise and its status as an educational toy.

base, and the speed thus follows a 'natural' sloping descent, whose shape depends on the technical configuration (weight and size of the base, any rubbing involved, etc.). Only the presence of a crank makes it possible to control the speed of rotation – control that is only relatively precise, but real. At the same time, the operator/viewer must continue to turn the crank throughout the show (or, later, throughout the take with a camera). The form of the movement seen is thus no longer that of the deceleration typical of the machine, but rather the form of the user's own gesture, which one can strive to correct to the point of perfect regularity, or amuse oneself by altering in order to see the effect on the moving image or on one's fellow viewers – for although some of these toys were *dispositifs* designed for several viewers, one of these viewers, the person operating the machine, had a special status. And this role was even more individualized when there was a crank to turn.

Thus, the addition or not of a crank to a machine produced a series of transformations in what it showed and in the role of the viewer or viewers. A zoetrope or Praxinoscope without a crank were not so much machines presenting shows of moving images as they were machines *putting images into motion*. Set and kept in motion before gently returning to immobility, the drum constantly highlighted the animation of the images itself, making the machine function as a toy for comparing the series of fixed images, to which one always returns, with the ephemeral 'animated picture'. The point of the activity was thus the *transition* between them.

Hand-cranked machines presented a show of a certain duration, fixed by the user, in which one could admire not only the way the images were put into motion, but also the attractiveness of the scene and the delicacy and perfection of the drawing – and this required a machine capable of producing this show in a manner relatively comfortable for the viewers' eyes.

In this way, the entire question of fixed images/moving images was embodied in the way these machines were conceived: the question of the presence of the elementary image in the moving image. This is also why, in the 1950s, the filmmaker and artist Robert Breer, whose films explored this problem of the status of the photogram very closely,[89] began making Mutoscopes,[90] sometimes with the help of Jean Tinguely. The Mutoscope, unlike the

89 In exemplary fashion in what is undoubtedly his best-known film, *Récréation*, 1956-1957 (16mm, colour, 2 minutes, commentary by Noël Burch).

90 See Brigitte Liabeuf et al., *Robert Breer: Films, floats & panoramas* (Montreuil: Éd. de l'oeil, 2006), 48-49.

Kinetoscope, is essentially a cranked instrument that enables the viewer, fascinated but always physically active, to watch the composition itself, through the form of his or her gesture, of the animated movement. Gaumont had begun marketing its version of the Mutoscope in 1900, with a spring mechanism based on the Lumière brothers' patent for the Kinora of 1896, but it soon opted for hand-crank operation.[91]

Other artists, moreover, have made their own versions of these optical machines, albeit on the basis of very different principles, sometimes employing quite original driving solutions, such as the *Mini Rotary Psycho Opticon* created in 2008 by the Canadian artist Rodney Graham and operated by pedals![92]

As for motor-driven machines, these balance things out in yet another way: on the one hand, they make possible movement of a set duration at a constant speed, making it similar to hand cranking; on the other hand, the user's manipulation of the machine is limited to setting it in motion and stopping it, making its operation closer to that of a hand-operated machine.

The question of driving mechanisms would remain central after 1895 and was one of the problems common to viewing machines involving movement, from optical toys to moving picture cameras, projectors, and editing benches as cinema became culturally institutionalized and industrially rationalized. As mentioned above, this question was one of the manifest differences between Edison machines with their electric motors and the hand-cranked Lumière Cinématographe. This needs to be related to the different means of commercializing the devices and to their target audiences: the Kinetoscope presented a show, whereas the Cinématographe was initially conceived for the amateur photographer who would not be put off by the hand crank and who undoubtedly would appreciate the subtle art of handling it.

Rival machines would generally adopt the hand crank, and attempts were made to find the best form and positioning for it. In Germany, Max Skladanowsky placed the crank of his Bioskop at the front of the machine, below the shutter, putting the operator's body in a position of monitoring the machine instead of the screen. Louis Lumière positioned the crank of the Cinématographe at the rear of the device, slightly to the left. This choice

91 Gaumont produced its hand-cranked Kinoras 'by hand' until 1910 (the George Eastman Museum in Rochester, New York, preserves a unit dated by it to that same year).

92 This indoor bicycle driving a series of abstract discs, whose mechanism is reminiscent of Marey's odographe, was shown in the exhibition *HF/RG* [*Harun Farocki/Rodney Graham*] (curated by Chantal Pontbriand) at the Jeu de Paume, Paris, 7 April to 7 June 2009. Unfortunately, it was forbidden to put the machine into operation.

may initially seem impractical, but we must not forget that this camera had no viewfinder. The scene was framed before shooting, with the camera open, by looking through the exposure window (this was also when the image was focused); the film was then put in place, the device closed up, and the 'kinematography' was carried out standing up looking directly at the subject. The body was thus kept at a fair distance from the camera; the operator was not 'glued' to it. Once again, we must take into account the machine as a whole, the way its form and uses are connected, in order to understand its internal logic. This position at the rear of the device was taken up only one other time, to my knowledge – with the Pathé professional camera, but this camera was highly esteemed and very widely used after 1908 and right into the 1920s, being adopted in particular by Billy Bitzer, D.W. Griffith's famous camera operator.

In England, Robert William Paul and Birt Acres placed their crank to the side, which became the most common spot afterwards – on the right-hand side, bringing the operator's body hard up against the machine, particularly after the introduction of viewfinders. Finally, it would hardly be a caricature to state that the history of moving picture cameras has largely consisted in gradually 'merging' the machine with the operator's body, whereas the history of projectors, and the abandonment of the crank in projection booths, would, on the contrary, enable the projectionist to move away from the machine – and enable the exhibitor to have one projectionist tend more than one machine.

Naturally, other solutions for the position of the crank were sometimes adopted; for Raoul Grimoin-Sanson's 'Cinéorama', for example, which comprised ten cameras running simultaneously to cover a 'complete' 360° field of vision, the crank was located below the machinery and operated by three people.

In the context of cranks, as in others, Étienne-Jules Marey was an exception: Marey did not much like hand-cranking, preferring spring, weighted, or electric motors, which guaranteed greater precision and made possible a greater number of speeds and steadier start-ups. His machines were sometimes equipped with cranks, but these were for rewinding the mechanism, not for directly driving it.

The driving system adopted sometimes presented a few surprises: it turned out that the Lumière Cinématographe's mechanism was one of the few able to operate backwards, something each operator, beginning perhaps with Louis Lumière, appears to have discovered as an unforeseen oddity of the machine and making possible quite amusing effects: a demolished wall magically rebuilding itself, for example.[93] Thus, it was the form of the machine, to

93 *Démolition d'un mur* (*Demolition of a Wall*) is one of the pictures Louis Lumière attributed to himself in the catalogue he gave Georges Sadoul in 1946. It shows the collapse of a section

adopt André Gaudreault's terms, which led Lumière to leave behind the 'capturing-restoring paradigm' that appears to have governed his thinking.[94]

In the end, the crank found a fairly stable place and proportion and remained the preferred means of driving cameras and projectors throughout the 'silent' film period, until the late 1920s; notwithstanding all the questions related to the way in which it should be handled and that foreground the inherent tension in cinema between the principle of the reversibility of camera and projector and, in practice, the dissymmetry that led each practice and machine in a different direction from the other. Camera manuals and instructions emphasized the difficult and unjustly scorned art of crank-turning and the absolute need for regularity, whether one was filming a turtle or a horse race, a funeral or a ball. This artistry was made even more difficult because it was executed quite quickly; the mounting of the camera made it possible to carry out horizontal pans and vertical tilts, which had to be done with two cranks. An operator thus needed three hands, creating several problems that were solved by occasional human or electric assistance of varying degrees of encumbrance. The artistry of hand cranking sometimes made it necessary, for example, to add weight to a machine to give it stability, something already foreseen in the 1897 Lumière Cinématographe *Notice*: the crank had to be turned 'taking care to hold the device firmly with the left hand, pressing on its legs, to avoid shaking' (Illus. 41).[95] In this case, the Lumière machine's legendary lightness worked against it.

Projection manuals also insisted on regularity to achieve 'natural' movement, but allowed for and sometimes even suggested 'expressive' variations in the cranking speed. If we retain this distinction between shooting and projecting, we can grasp just how subversive this statement by Dziga Vertov in 1923 was:

> Until now a cameraman has been criticized for having filmed a running horse moving with unnatural slowness on the screen (rapid cranking of the camera) – or for the opposite, a tractor plowing a field too swiftly (slow cranking of the camera), and the like.

of a wall in the Lumière factory. Today, there are two known versions, dating from early 1896 and numbered 690 and 691 in the catalogue published by Michelle Aubert and Jean-Claude Seguin, *La Production cinématographique des Frères Lumière* (Paris: Mémoires de cinéma, 1996) (pp. 215-216), in which several quotations from reviews confirm that they were commonly projected forwards and then backwards.

94 On this paradigm see in particular André Gaudreault, *Film and Attraction*, 56ff.

95 Louis and Auguste Lumière, *Notice sur le Cinématographe Auguste et Louis Lumière*, 19.

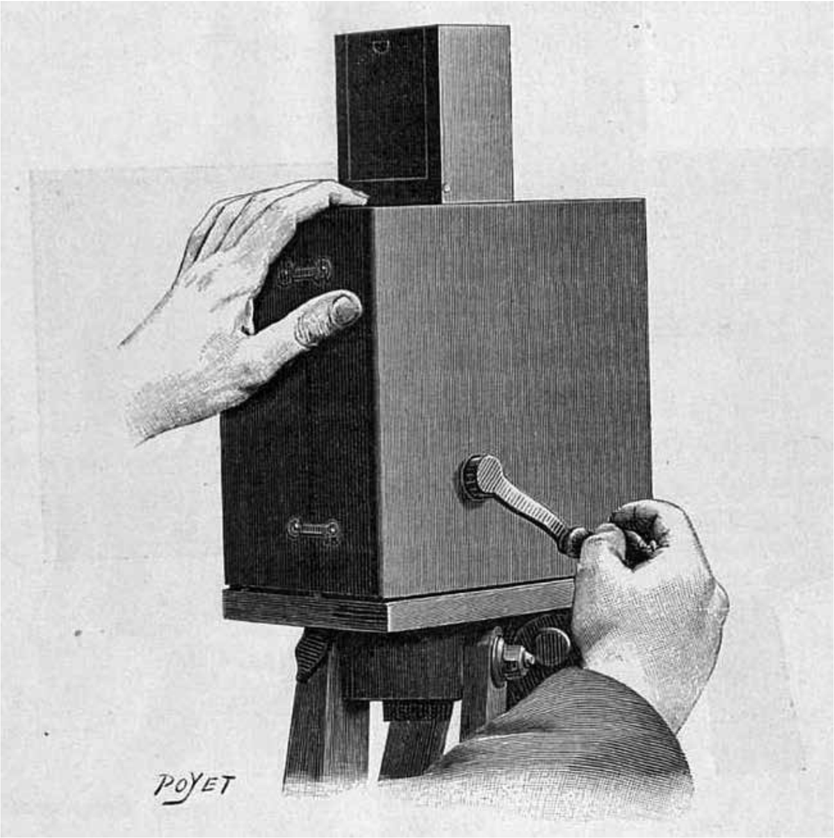


Illustration 41 – Instructions pour l'usage de la manivelle du Cinématographe. Notice, 1897.

> These are chance occurrences, of course, but we are preparing a system, a deliberate system of such occurrences, a system of seeming irregularities to investigate and organize phenomena.[96]

Amusingly, here, Vertov associates ('creates a montage of') Eadweard Muybridge's topos of the galloping horse with the agricultural mechanization so crucial to the Soviet Union, reversing, *through the action of the crank*, the traditional association of speed with the horse and slowness with the tractor in a more politically 'progressive' version. One reason the film industry, then in the process of being institutionalized, forbade these variations while

96 Dziga Vertov, *Kino-Eye: The Writings of Dziga Vertov*, trans. Kevin O'Brien (Berkeley, CA: University of California Press, 1984), 15-16.

shooting is that they are absolutely impossible to correct: if the taking speed is too high, no variation in the speed in projection, or in the laboratory, will make it possible to recover 'natural' motion. Power such as this – whose politically explosive possibilities Vertov sets out here – could not be granted to camera operators.

The hand crank made possible more than variations in speed: it had no fixed setting, no 'default' rate. It also enabled the machine to be reactive and autonomous, independent of electric power sources. Electric motors became widespread only when the arrival of the 'talkies' imposed a constant and automatic speed of 24 frames per second. This resistance of camera operators to electrification is an example of the 'margin of indetermination,' which, unlike automatism, according to Gilbert Simondon, is the real value of a machine:

> Worshipers of the machine commonly present the degree of perfection of a machine as proportional to the degree of automatism […]. Automatism, however, is a rather low degree of technical perfection. In order to make a machine automatic, one must sacrifice a number of possibilities of operation as well as numerous possible usages. Automatism […] possesses an economic or social signification more than a technical one.[97]

Automatism is not connected to any real technical element, but rather to an imaginary of the technical that can be dominant at a given historical moment – a technical object operating with no human presence, liberating humans from the burden of the repetitive and the arduous. This imaginary, and the range of creations it brings in its wake and produces, constitutes an orientation of the social at a point in history. There exists a politics of the machine connected to its modes and uses, and to the issues around its conception.

The Lens

While we can find in contemporary discourses a descriptive or normative discourse on the hand crank from the uses described therein, another element of the Cinématographe machine has disappeared almost entirely: its lens. The lens is never described, even by the Lumière brothers themselves in any of their texts. A few indications appeared in the 1897 *Notice*, solely

97 Gilbert Simondon, *On the Mode of Existence of Technical Objects*, 17.

with respect to projection. This silence extends throughout the entire historiography: even in a technical brochure as abundant and precise as that created by Jacques Foiret for the Musée national des techniques in Paris in 1988,[98] which details calculations of the mechanical resistance of celluloid – an issue, as we have seen, of extreme importance – there is no discussion of the lens. Only Vincent Pinel has mentioned a few characteristics of the lens in a text published in 1996.[99] Yet, the lens, and in particular its focal length, would largely determine the spatial organization of the projection, and thus the mode in which the cinema screening unfolded.

I would like to take a somewhat 'canonical' concrete example: the Lumière Cinématographe and the mythical performance of 28 December 1895 in the Salon Indien of the Grand Café in Paris. In fact, we have rather little in the way of concrete information about this screening; this obscurity is rather fitting for its quality as a founding myth. We know, Laurent Mannoni reminds us, that 'according to Clément-Maurice thirty-three curious people paid to get in at the price of 1 Franc.'[100] Those putting on the event consisted of the above-mentioned Clément-Maurice at the cash, Charles Moisson on the crank, and Jacques Ducom at the Molteni lantern, because the position of the Cinématographe's crank meant that the projectionist could not monitor the lamp at the same time. Its position at the rear of the machine meant that the operator's body was facing the machine or the screen but could not easily turn towards the back of the *dispositif*, and thus towards the lantern. The precise programme of this initial screening is not clear, not least because the Salon Indien was later demolished the architectural configuration of the room is difficult to determine precisely. One question in particular seems to me to be important: where was the projector?

Paul Paviot, reconstructing the site for his film on Lumière in 1953, placed the projector in the middle of the room, in the midst of the viewers. This is consistent with a certain notion of this so-called novelty period, devoted to the demonstration and thus supposedly to the exhibition of this new *dispositif* with extraordinary powers.

The most accurate information we have about the arrangement of this room no doubt comes down to us from a letter from Ludwig Stollwerck to John Volkmann, written in Cologne on 16 April 1896, three weeks after

98 Jacques Foiret, *Cinématographie: La caméra des freres Lumiere. Inventaire 16966* (Paris: Musée national des techniques, 1988).

99 Vincent Pinel, 'Louis Lumière, la photographie et le Cinématographe', in Jean Gili, Michèle Lagny, Michel Marie and Vincent Pinel, eds., *Les Vingt Premieres Années du cinéma français* (Paris: Presses de la Sorbonne Nouvelle, 1996), 386.

100 Laurent Mannoni, *The Great Art of Light and Shadow*, 461.

a visit to Paris. Stollwerck, who most likely attended a screening of the Cinématographe, for which he had signed an exclusive exhibition contract for Germany, describes this 'underground billiard parlour' as a 'space twelve metres by eight' with '180 seats and thirty or forty standing room spaces.' This is already astonishing: one can imagine fitting 100 to 120 people in a room 96 metres square, but 180 seems like quite a lot, even if we suppose they were sitting on benches and not chairs, and especially for a room being used continuously for several years.

According to Stollwerck, pictures (*Bilder*) were projected in this room 'onto a wall 280cm wide and two metres high.'[101] Auguste Lumière, in a letter dated 18 December 1895 about the screenings being planned in Paris, wrote that 'the images will be projected in various sizes, two metres in breadth being the largest obtainable.'[102] A screen whose 'average dimensions are two metres horizontally and one metre, sixty centimetres vertically'[103] was still being mentioned in the notice published when the machine began to be marketed in 1897. Did Stollwerck overestimate the size of the projected image? Or was the two-metre screen placed on a 2.8 metre wall? Or did the screen set up by the Lumières contradict their own descriptions?

The other document we have of the way the room was organized is a drawing made well after the event, in 1970, by Léopold Maurice, the son of Clément-Maurice.[104] In fact, the two sources are difficult to reconcile: in Maurice's drawing we see 'the 'rather steep and unpleasant stairway' mentioned by Stollwerck, but the room seems smaller in proportion to the screen, and arranged differently. Maurice, in any event, indicates the place occupied by the projector: at the back of the room, behind the viewers. This arrangement is corroborated by the description of the Paris screenings by Henri de Parville in *Les Annales politiques et littéraires* of 26 April 1896:

> In the boulevard hall where at this moment the cinématographe is operating, viewers are facing a white screen. Behind them, the device

101 Letter from Ludwig Stollwerck in Cologne to John Volkmann in New York, 16 April 1896, translated from the German by Félix Stürner, in Martin Loiperdinger and Roland Cosandey, eds., 'L'introduction du Cinématographe en Allemagne: De la case Demenÿ à la case Lumière: Stollwerck, Lavanchy-Clarke et al., 1892-1896', *Archives* 51 (November 1992): 9.

102 Auguste and Louis Lumière, *Letters*, 74.

103 Louis and Auguste Lumière, *Notice sur le Cinématographe Auguste et Louis Lumière*, 29; and Auguste and Louis Lumière, 'Le Cinématographe', 258.

104 Two slightly different versions of this drawing have been published: Jacques Rittaud-Hutinet, *Le Cinéma des origines: Les frères Lumière et leurs opérateurs* (Seyssel: Champ Vallon, 1985), 33; and Bernard Chardère, Philippe Dujardin and Lucette Lombard-Valentino, eds., *Lumière, le cinéma* (Lyon: Institut Lumière, 1992), 73.

> has been set up in a booth draped in velvet, and the projection is carried out through a barely visible hole over the heads of the viewers. In this way, the cinématographe is hidden from view, and the audience sees only the projections. Many people imagine mistakenly that the photographs are applied behind the screen. Not at all; they are behind their backs and come out of the booth, which one barely notices, and are reproduced on the screen.[105]

Parville's insistence on the way the *dispositif* was concealed and its effect on the viewers leaves little doubt as to its veracity in April 1896 (but was this configuration already in place in December 1895?). It also informs us about the ignorance of the principle of projection for some viewers of the Cinématographe in 1896, despite the previous existence of the magic lantern. Of course, the Lumières' desire to conceal the projector so carefully – a concealment compensated, according to Georges Sadoul, by a brief leaflet describing the machine's mechanism, posted on the door and on the programmes[106] – was not neutral.

An analysis of the Cinématographe machine itself, and in particular of that central element the lens, could help to untangle these questions, or complicate them further.

The mass-produced Cinématographe constructed by Jules Carpentier was equipped with a lens described as 'standard' (Illus. 42), about which no source or characteristic was noted at the time, and which bore 'no mark or possibility of identification.'[107] Its focal length[108] became known only after the fact, thanks to Dr. Paul Genard, who had it estimated by technicians at the Conservatoire national des arts et métiers (CNAM): it was 58mm. For an image measuring 24mm by 18mm, this was already long, requiring tight framing or a relatively considerable distance from the subject. The 'normal' focal length for this format, i.e. one that would create perspective seen as close to that of human vision, would be closer to

105 Henri de Parville, 'Le Cinématographe', *Les Annales politiques et littéraires* (under the heading 'Mouvement scientifique: Inventions et découvertes'), 26 April 1896, 270.

106 See Georges Sadoul, *Histoire générale du cinéma*, vol. 1, 238.

107 Vincent Pinel, 'Louis Lumière', 386.

108 The focal length of an optical system is the distance between the centre of a curved lens and its focus. For objects at a great distance, which by approximation we might think of as infinite, it is the distance between the centre of the lens and the plane on which the images form, meaning the film stock. The focal arrangement of the lens/size of the base on which the image is being impressed determines the lens' field of vision. For a given image format, a 'short' focal length lens will have a wide angle and a 'long' focal length lens will have a narrow field of vision.

Illustration 42 – The Cinématographe's standard lens.

30mm. To translate these figures into present-day norms which speak better to us, 58mm would be the equivalent of an 83mm lens for a photograph measuring 24mm by 36mm,[109] for which the 'standard' would be around 45mm. This choice of a long focal length does not directly correspond to amateur photography visual practices at the time: the first Kodak camera marketed by Eastman in 1888 was, according to the George Eastman Museum, equipped with a 57mm lens for an image 68.5mm in diameter on a strip 70mm wide – the equivalent a 38.5mm lens for a 24 by 36mm image, a slightly short focal length. We should recall that Dickson, for example, was the first to use the flexible and transparent celluloid film

109 This '24 x 36' standard is the dominant form of 35mm photography on film, whose images measure 24mm by 36mm, with the film advancing horizontally. This standard continues to be used even in digital photography, for which cameras for amateurs today nevertheless use sensors of smaller or even much smaller size. But the photographers who purchase and use these machines are still accustomed to this standard and understand what kind of framing they can create at a given distance from the subject with an '80mm equivalent' lens, for example.

(modifying its width and perforating it), manufactured by Eastman for its Kodak camera, with the Kinetoscope. This width and these perforations were later adopted as the norm in photography, after they were established for moving pictures.

Lumière's preference for a long focal length, giving a narrow field of vision, required tight framing or a relatively considerable distance from the subject; it meant that the operator had a strong sense of the frame. This preference is even more remarkable given that, as mentioned above, the Cinématographe had no viewfinder, complicating the framing process considerably.

Today, devices with fixed optics, from the Apple iPhone to the Leica X1/X2,[110] have relatively short focal lengths, making it possible to obtain a wide field of vision. In the case of the Cinématographe, no alternative appears to have been offered for taking pictures. The buyer could choose a Zeiss lens (Anastigmat, with an iris diaphragm), an example of which is currently held by the Institut Lumière (Illus. 43); its focal length is 43mm. The very first prototype built by Moisson, also preserved at the Institut Lumière in Lyon, was equipped with a Voigtländer Collinear II lens (Illus. 44), with a similar focal length (50.6mm).[111] The second prototype, on the other hand, used from March to December 1895 and deposited at the CNAM by Louis Lumière himself in 1948, unfortunately no longer has its original lens, but the consistency in the focal lengths employed suggests that it would also have been around 50mm.

The choice of lens came into play for projection specifically in the case of the Cinématographe for one reason in particular: once again, the *reversibility* of the Lumière machine. Étienne-Jules Marey, describing this principle in

110 The X1 was introduced in 2009 and the X2 in 2012. These Leica cameras have APS-C sensors (23.6mm x 15.8mm), or a format much closer to cinematic images than to traditional photography, and a lens with a 24mm focal length, described by the manufacturer as 'equivalent to 35mm' – and thus equivalent to the 24 x 36 format.
Leica's competitors (Fujifilm X100) have adopted a similar focal length. This choice, which departs from the idea that a camera with a fixed lens should necessarily be equipped with a 'standard' focal length, is tied up with the history of Leica, whose cameras were used most of all for photographic reportage, in which one tends to use such focal lengths predominantly, making it possible both to 'capture' a moment or 'scene' as a whole, as one is relatively close to the protagonists, and to not have to break up the scene too much while at the same time preserving the sense of the frame. These devices are thus unusable, for example, for animal photography, which requires long focal lengths in order to be able to photograph even a small subject from a great distance.

111 My warm thanks to Jean-Marc Lamotte of the Institut Lumière for providing me with this information.

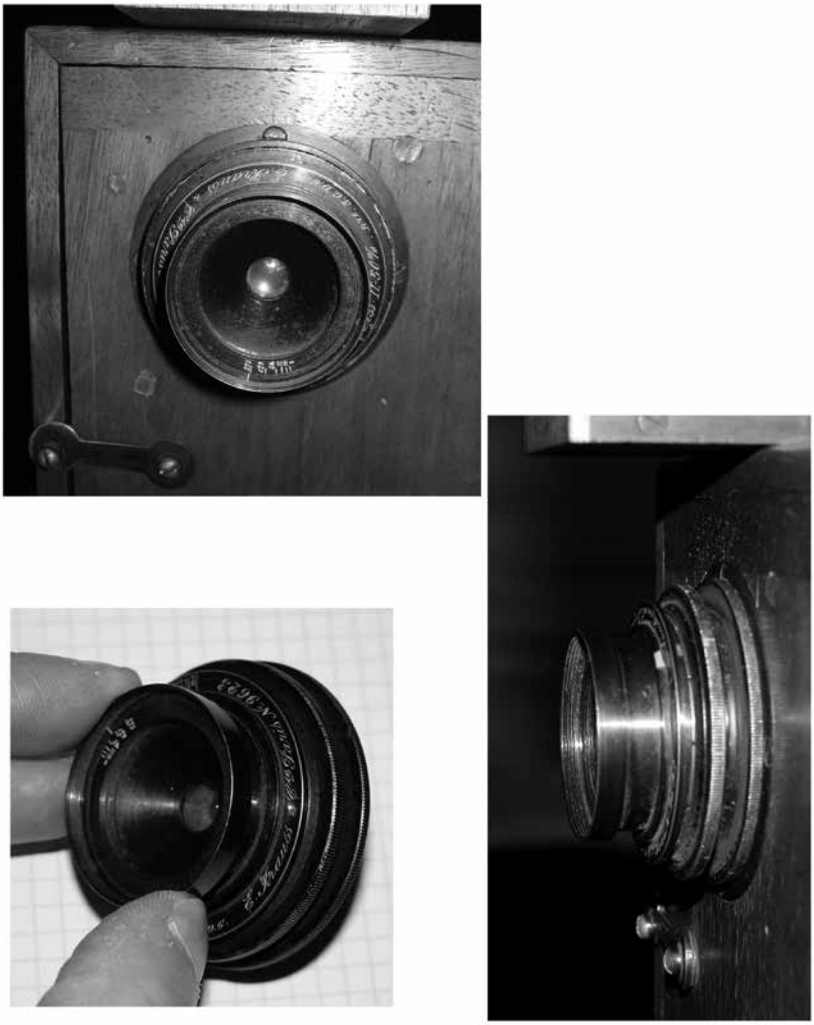


Illustration 43 – The Zeiss lens, optional for the Cinématographe. Photographs by Jean-Marc Lamotte, Institut Lumière.

the passage from *Le Mouvement* partially quoted above, drew a singular conclusion from it:

> This device, which is used to analyse movements, is reversible, at least in principle, and could be used to reconstitute them. Suppose that a strip of film loaded with positive images passed in front of the lens and that this strip was strongly lit from behind; the images would be projected,

Illustration 44 – The Voigtländer lens on the first prototype of the Cinématographe. Photographs by Jean-Marc Lamotte, Institut Lumière.

> life-sized, onto a screen placed at a distance equal to that of the object whose movement had been photographed.[112]

Thus, the reversibility of the machine involves not only its mechanism. It is founded theoretically on the optical principle of the reversibility of light,

112 Étienne-Jules Marey, *Le Mouvement*, 309.

which guarantees that if the object and the screen are placed the same distance from the device the projection will be *exactly life-sized*. The interest of reversibility is also just as understandable from Marey's perspective as it is from that of a 'cinema' devoted to the *identical reproduction* of scenes in motion. The connection between 'cinema' and projection, moreover, would play out concurrently on these two levels: moving photographic images must be projected in order to be visible by 'an entire assembly,' but also to appear 'life-sized'. This is another epistemologically important concept in the constitution of the 'cinema' problem.

For this to be true, however, it is obviously understood and crucial that the lens used both for taking the picture and for projecting it be the same.

If we were to imagine, based on all of the above, that projection was carried out with a Cinématographe equipped with a 'standard' lens and onto a screen two metres tall, a simple calculation enables us to conclude that the Cinématographe was placed at approximately 4.65 metres from the screen. This is in keeping with André Gay's description of the 11 July 1895 meeting of the *Revue générale des sciences*, after which 'its images were projected onto a screen five metres away.'[113] We might, therefore, think that these early demonstration projections were held with the principle of reversibility determining the configuration, as the lens for shooting the picture was used again for the projection.

In the Salon Indien, however, and according to the account provided by Stollwerck, the size of the room meant that the projector was not at the back but rather closer to the front, visible to all and even, one might say, on display, in a configuration close to Paviot's reconstruction. But early on, and perhaps from the beginning, Lumière chose a different configuration and decided to conceal the machine at the back of the room.

This would require an additional step: changing the lens. This step was necessarily delicate and could make the machine vulnerable to damage; one consequence, for example, is that, today, a sizeable number of

113 André Gay, 'Le Cinématographe de MM. Auguste et Louis Lumière', *Revue générale des sciences pures et appliquées* (under the heading 'Actualités scientifiques et industrielles') 6, no. 14 (30 July 1895): 636. Further on, Gay writes: 'A little girl, depicted *life-sized*, was especially successful' (my emphasis). The film was *Repas de bébé* (*Baby's Dinner*, no. 655 of the catalogue edited by Michelle Aubert and Jean-Claude Seguin, *La Production cinématographique des frères Lumière*). A 'review of a projection in the Lumière establishment at La Ciotat' published in *Le Petit Marseillais* on 24 September 1895 indicates that the screen was 'at a distance of seven or eight metres' from the Cinématographe. See Bernard Chardère, Philippe Dujardin and Lucette Lombard-Valentino, eds., *Lumière, le cinéma*, 34.

Cinématographes held in archives (CNAM, Institut Lumière, etc.) have lost their original lens.

When the Cinématographe was marketed in 1897, it came with a lens for 'obtaining negatives' and another for projection. The former standard or Zeiss lens was described above; the latter came in a choice of three options: short, medium, or long focal length. For a two-metre high screen, the short focal length lens put the projector at a distance of eight metres, the medium at 10.5 metres, and the long at fourteen metres. The focal lengths were 100, 130, and 175mm respectively.[114] The choice of lens when purchasing the machine depended on the room in which the show would be projected and the way this room would be arranged.[115] For the first projection in England, in the Great Hall of the Polytechnic Institute on 21 February 1896, the projector was already at the back of the room, some eighteen metres from the screen, for an image six feet (1.8 metres) high[116] with a focal length of 250mm.

It thus appears that the Lumières almost immediately envisioned projection with the Cinématographe in a cultural context whose dominant conception of this kind of performance required that the machinery be hidden at the back of the room. This conception had to have been quite strong, during this supposed 'novelty period', for Lumière to yield to it even when it went against the fundamental principle of reversibility – unless this principle,

114 Auguste and Louis Lumière, *Notice sur le Cinématographe*, 27. The notice does not give the same focal lengths as those from the calculations above but shows a table giving the 'dimensions of the image' for each focal length according to the 'distance between the screen and the device'. The screen-device distances given vary from 5.80 metres (for the 'short focal length') to a little more than twenty metres; the dimensions of the image range from 1.50 x 1.15 metres to 6 x 4.50 metres (for the 'short focal length').

115 A poster advertising the Cinématographe, reproduced by Jacques Rittaud-Hutinet and dated by him to 1897, announced that the special Cinématographe for projections was equipped, apart from its lens, with 'an additional optical lens placed behind the lens [which] makes it possible double at will the latter's enlargement, so that a single lens can give two different enlargements.' Jacques Rittaud-Hutinet, *Le Cinéma des origines: Les frères Lumière et leurs opérateurs* (Seyssel: Champ Vallon, 1985), 64.

116 Joost Hunninger, 'Première on Regent Street', in Christopher Williams, ed., *Cinema: The Beginnings and the Future; Essays Marking the Centenary of the First Film Show Projected to a Paying Audience in Britain* (London: University of Westminster Press, 1996), 49. Charles Musser reproduces the floor plan of an exhibition space set up by W.R. Miller for the Vitascope in Nashville, Tennessee, in 1896. The projector is in a cabin behind the room, not centred to the screen. The device-screen distance is 78 feet, or nearly 23.8 metres, and the screen is 12 feet tall, or 3.65 metres. See Charles Musser, *The Emergence of Cinema: The American Screen to 1907* (Berkeley, CA: University of California Press, 1994), 127.

which held concretely for the mechanism, was put to only limited use in the machine's optical elements (depth of focus, quality of the light cast on the screen, etc.).

In a sense, this masking of the *dispositif* is part of a more general tendency in the Lumière company. Its counterpart in the shooting stage can be seen in injunctions not to look at the camera, deriving from the aesthetic of the 'stolen moment' that arose with the photographic snapshot.[117] Vincent Pinel points out that Paul Génard had 'discovered the complete similarity' between the Cinématographe's standard lens 'and a Darlot lens made for a miniature still camera which indiscreet people in fin de siècle France wore under their neckties'[118] – perhaps the Stirn 'Concealed Vest Camera', which entered into production in 1886.[119] Lumière's capturing-restoring, to use André Gaudreault's vocabulary, brings two parallel paradigms together: showing and concealing.

As a result, the way the Lumière machine was organized bears the trace, in its form, of practices of the day in related fields: photography and projection shows (magic lanterns). The inventors' assumptions were never set out clearly by them, as these no doubt presented themselves to them as 'natural', bearing the stamp of the obvious cultural paradigm in which they worked. This imaginary of what the film show 'should' be led them to decide their device's mechanisms. And while the internal organization of these mechanisms is tied up with epistemological issues that are no less historical, the outer mechanisms of the device tied it directly to the cultural situation in which it took part when it emerged.

There was thus a series of continuities and ruptures that elaborated the form the Cinématographe took, and the form taken by the show produced by the machine. The form of the machine could be decisive with respect to several points. In the case of others, the explicit or implicit 'imperatives' of its use led inventors to modify their machine in order to adapt to these imperatives. Here, the fundamental reversibility had to be constrained, with specific lenses offered for obtaining negatives in one case and projecting positives in the other – before the two machines became independent of one another. In each case, a technological analysis of the machine itself as an *archive* best informs us about this dialectic and the issues it raises.

117 In conversation with André Gunthert, 16 May 2012.

118 Vincent Pinel, 'Louis Lumière', 386.

119 As suggested by Marie-Sophie Corcy of the CNAM in an e-mail to the author on 31 May 2012.

My goal here is not to overplay the role of the Cinématographe, or to try to give back to it the unequivocal status as 'the invention of cinema' it was granted for so long. My goal, rather, is not to discuss the legitimacy of this pivotal role attributed to the Lumière machine in historiography but to try, firstly, to *understand this historiographical operation itself as a historical fact*. It is clear that at the time of its emergence the Cinématographe was part of an already-constituted (and plentiful) lineage of technical matters and issues. It also seems clear that within this lineage this machine – as well as several others – was a singular 'technical individual' whose level of internal reorganizations, internal logic, and coherence confirm that it was, in fact, an *invention*. Because the evolution of machines and that of the problems they present themselves as solving are constructed along parallel lines, the Cinématographe, a remarkably concrete machine, was able to seem in the historiography of cinema like the simple and clear solution to the 'cinema' problem. This solution would have to be improved, reformulated, re-arranged, taken apart, and put back into play when culture and industry required it. It was a solution that could also be rejected, debated, and circumvented by inventors set on organizing their machines differently because this one, in their view, did not solve the problem, or, at least, solve the 'right' problem.

One cannot opt for a continuous historiography by erasing the rupture represented by the Cinématographe (along with several other machines) without simply reintegrating it into an undifferentiated flow of machines. This flow is itself an interesting phenomenon of cultural history, but its lack of differentiation cannot in any way account for the different forms of the machines and of the problem, of their transformations and implications. Ultimately, it can tell us nothing about the real epistemological conditions in which machines and problems were concretely conceived.

5. 'Natural Colour Kinematography', a New Cinema Invention: Kinemacolor, Technical Network and Commercial Policies

Abstract
Kinemacolor, the first commercially exploited 'natural colour' process, has often been considered as a step in the wrong direction for colour cinema. But it was an extraordinarily coherent system, based on a mechanical apparatus and involving a whole conception of what cinema was, what it should be, how it should be done and sold, and what was to be its place within culture. Moreover, the characteristics of the process involved highly original perceptual traits that are of major theoretical interest today. Technically invented by George Albert Smith, it was its promoter Charles Urban that gave it its real coherence. For Urban, Kinemacolor was conceived as a true reinvention of cinema. Cinema thus never ceases to be confronted with reinvention projects.

Keywords: Kinemacolor, Charles Urban, George Albert Smith, technical network, colour cinema, film technology.

In the introduction to his doctoral dissertation on 'the conquest of the snapshot', the photography historian André Gunthert writes:

> Any photographic image, the product of technique, contains an ensemble of information about the operational modalities which presided over its creation: an iconic document offered up for aesthetic reading, it is also a technological monument capable of becoming the subject of an archaeological interrogation.[1]

1 André Gunthert, 'La Conquête de l'instantané', 12.

Turquety, B., *Inventing Cinema: Machines, Gestures, and Media History*. Amsterdam: Amsterdam University Press, 2019.
DOI 10.5117/9789463724623_CH05

This 'also' is tied up with a shift: the attention to the technological, to its traces in the image, transforms our gaze and has us move to the archaeological level. But this passage involves taking non-verbal elements into account: images, devices, diagrams, graphics, etc. Pierre Francastel, in his article 'Valeurs sociologiques de l'espace-temps figuratif', clearly demonstrated the importance of these non-verbal sources, and yet they create methodological problems as part of an archaeology: how (and of what) can they make an archive? It was questions of this sort that led Michel Foucault to pass from an archaeology based on discourses to an epistemology that takes *dispositifs* into account. I would like to give an example, using a concrete object, to illustrate these questions, one sometimes mentioned by archivists because of the singular problems it poses:[2] the first cinematic natural colour process marketed commercially, Kinemacolor.

This process was invented in 1906 in England by George Albert Smith and was financed and marketed by Charles Urban until 1915. Its first public, commercial presentation was at the Palace Theatre in London on 26 February 1909, and in subsequent years it went on to international success – a success, as Luke McKernan reports,[3] to which the funeral of Edward VII and the crowning of George V, in 1910 and 1912, contributed significantly, as only Kinemacolor was able to render their colourful pomp. In particular, the Delhi Durbar, an Indian ceremony to recognize the new British King as emperor of India, filmed in Kinemacolor in December 1911 and presented for the first time at the Scala Theatre in London on 2 February 1912, was an unprecedented triumph, exported to the United States, France, and elsewhere. It was 'probably the greatest success that moving pictures have scored at any time or place,' according to the American trade journal *Moving Picture World*,[4] even though the show lasted two and a half hours and admission was considerably more expensive than usual. This show won fame for Urban, along with the favour of the king.

2 See in particular Nicola Mazzanti, 'Raising the Colours (Restoring Kinemacolor)', in Roger Smither and Catherine A. Surowiec, eds., *This Film is Dangerous: A Celebration of Nitrate Film* (Brussels: FIAF, 2002), 123-125.

3 Luke McKernan, '*Something More Than a Mere Picture Show': Charles Urban and the Early Non Fiction Film in Great Britain and America, 1897-1925*, unpublished Ph.D. dissertation (London: Birbeck College/University of London, 2003), 135ff; and '"The Modern Elixir of Life": Kinemacolor, Royalty and the Delhi Durbar', *Film History* 21, no. 2 (2009): 122-136.

4 H.F.H., 'The Durbar in Kinemacolor', *Moving Picture World*, 2 March 1912, 774. Quoted in Eirik Frisvold Hanssen, *Early Discourses on Colour and Cinema: Origins, Functions, Meanings* (Stockholm: Stockholm University Press, 2006), 45.

George Albert Smith had been one of the most important film directors and producers in the nascent years in England, a 'pioneer' in the group Sadoul famously called the 'Brighton School'. Noël Burch in particular has also pointed out the importance of the film experiments carried out by Smith between 1897 and 1903: *The Miller and the Sweep* (1897); *Grandma's Reading Glass* (1900); *As Seen Through A Telescope* (1900); *Sick Kitten* (1903); and *Mary Jane's Mishap* (1903)[5] were some of the films distributed by the Warwick Trading Company. Smith, a member of the Royal Astronomical Society, was also known previously for his illustrated lectures on scientific topics.

A Technology of Kinemacolor

Around 1903, Smith, financed by Urban, began to devote himself to research into colour cinema. This research led to the filing of a patent application on 24 November 1906 for 'improvements in and relating to kinematograph apparatus for "the production of coloured pictures"' consisting of 'a practical method in which the well-known animated photographs or bioscope moving pictures may be projected in the colours of nature approximately instead of in black & white as usual.'[6] In this patent application, Smith described the steps of his procedure as follows:

> 1. An animated picture of a coloured scene is taken with a bioscope camera in the usual way, except that a revolving shutter [Illus. 45, fig. 1] is used fitted with properly adjusted red and green colour screens [filters] [Illus. 45, figs. 2 and 3]. A negative is thus obtained in which the reds and yellows are recorded in one picture and the greens and yellows (with some blue) in the second, and so alternately throughout the length of the bioscope film [Illus. 45, fig. 5].
> 2. A positive picture is made from the above negative and projected by the ordinary projecting machine which, however, is fitted with a revolving shutter, furnished with somewhat similar coloured glasses to the above, and so contrived that the red and green pictures are projected alternately through appropriate coloured glasses.

5 Noël Burch, *Life to Those Shadows*, trans. Ben Brewster (Berkeley, CA: University of California Press, 1990), 89-90, 147-149, 222-223.

6 George Albert Smith, British patent no. 26,671, filed 24 November 1906, granted 25 July 1907, and revoked 26 April 1915; 'Provisional Specification', p. [1], dated by Smith 22 November.

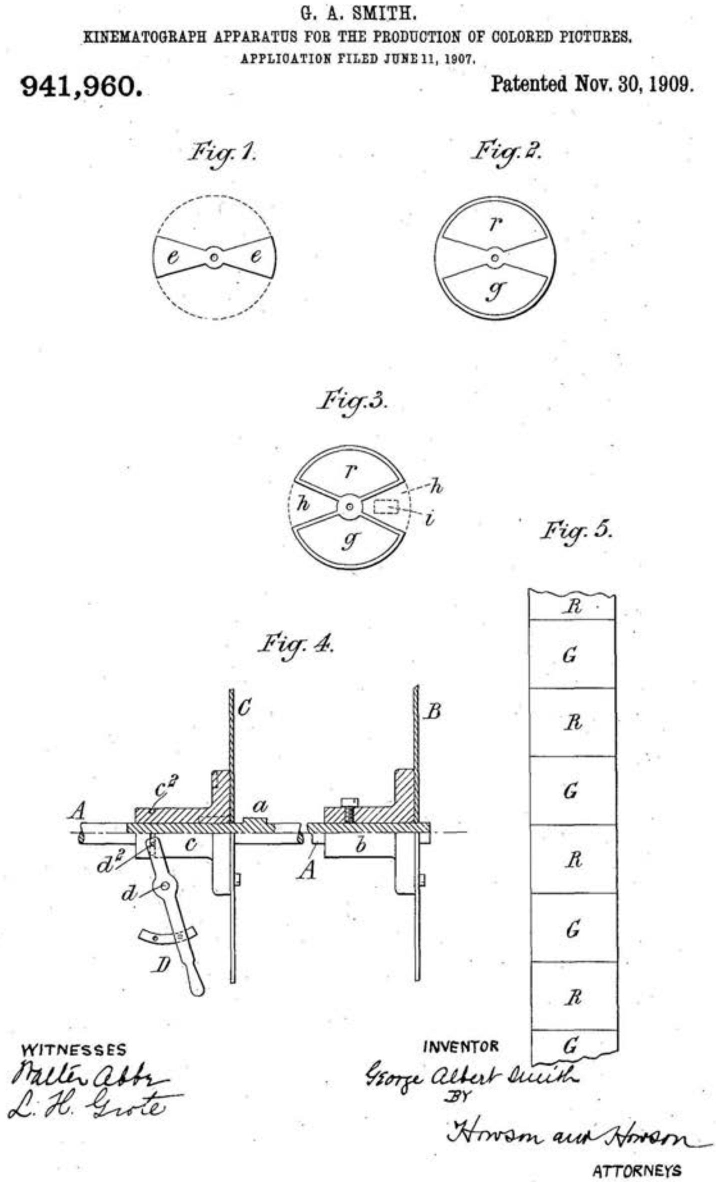


Illustration 45 – George Albert Smith, U.S. patent for Kinemacolor. Fig. 1: Traditional shutter. Figs. 2 and 3: Shutter with red (r) and green (g) filters. Fig. 4: Mechanism showing the two turning discs, single shutter coloured disc. Fig. 5: Principle of alternating the coloured selections on the strip.

> 3. If the speed of projection is approximately 30 pictures per second, the two colour records blend and present to the eye a satisfactory rendering of the subject in colours which appear to be natural.
> The novelty of my method lies in the use of two colours only, red and green, combined with the principle of persistence of vision.[7]

Kinemacolor involved specific equipment for both shooting *and* projecting film: a rotating shutter with red and green filters and a doubling of the speed of the film. These conditions had consequences: the filters absorbed a great deal of light, the shooting required well-lit conditions, and the projected images suffered from very poor luminosity on screen. The Kinemacolor film stock looked like ordinary black-and-white film, even though it had to be 'panchromatized', meaning it had to undergo chemical treatment to make it sensitive to red, something that was not necessarily the case at the time with so-called orthochromatic emulsion. I should emphasize that there is *no colour on the Kinemacolor film stock* (Illus. 46). This observation led Colin N. Bennett, in 1913, to describe Kinemacolor's colour as an *illusion* in a specifically cinematic sense:

> Thus, in the case of Kinemacolor, the willing member of the audience is treated to not one, but two separate and complete illusions, for whereas the black and white exhibitor merely makes you believe you see movement which is not there, the Kinemacolor operator does the same for the perception of colour also.[8]

The Kinemacolor procedure is a fascinating technical object of more than mere historical interest. In this sense, traditional technological film histories have shown little interest in the procedure beyond analysing its ultimate failure and the defects that can account for it, at least in part. Kinemacolor is described, primarily, as a step in the wrong direction, one of the many procedures attempting to create cinema in natural colours through an additive process. From this perspective, the crucial moment was when Herbert T. Kalmus, founder of the Technicolor company, finally understood in 1917 (in his version of events[9]) that the solution could only

7 George Albert Smith, British patent no. 26,671. See also the United States patent no. 941,960, filed 11 June 1907 and granted 30 November 1909.

8 Colin N. Bennett et al., *The Handbook of Kinematograhy: The History, Theory, and Practice of Motion Photography and Projection*, 2nd ed. (London: The Kinematograph Weekly, 1913), 303.

9 Herbert T. Kalmus, 'Technicolor Adventures in Cinemaland', *Journal of the Society of Motion Pictures Engineers* 31, no. 6 (December 1938). Reprinted in Raymond Fielding, ed., *A Technological*

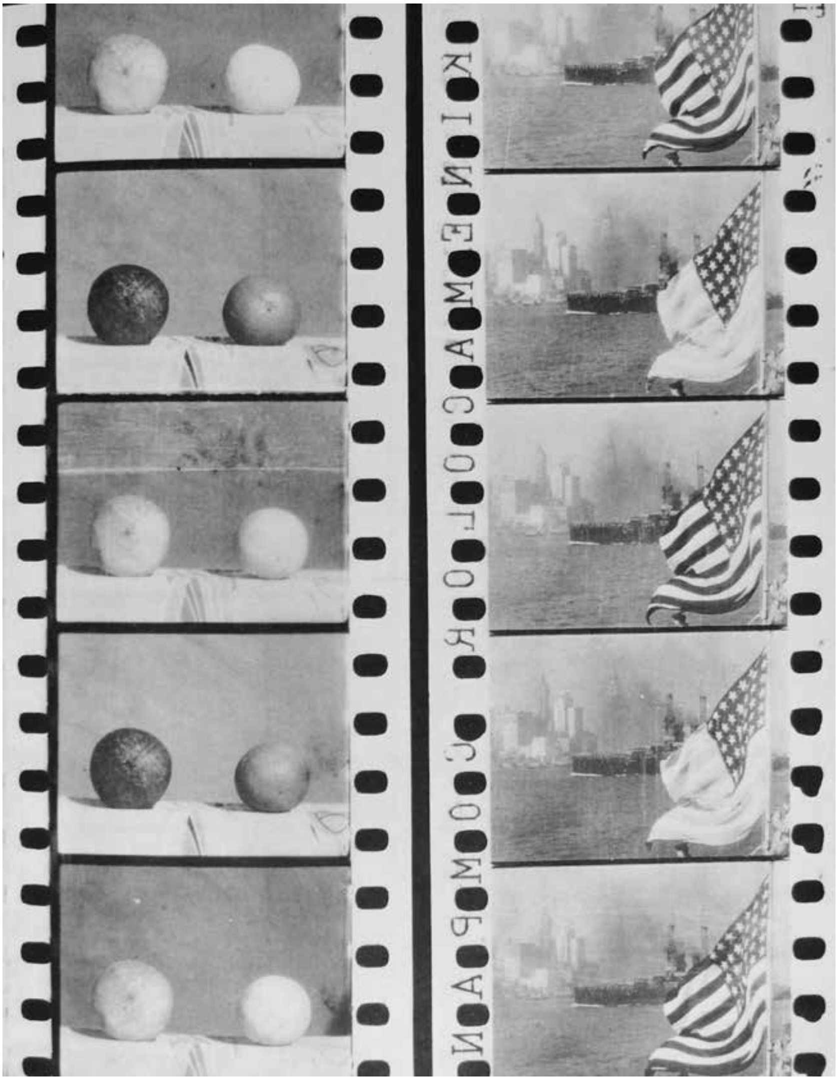


Illustration 46 – Examples of positive Kinemacolor strips. The succession of black and white coloured selections. From D.B. Thomas, 1969.

be a subtractive procedure, meaning that the colours should be present in the film stock itself, synthesized and *visible*, so that the film could be projected in a 'normal' manner. Kinemacolor simply went a little further than other additive procedures, to the point of commercial use whose

History of Motion Pictures and Television: An Anthology from the Pages of the Journal of the Society of Motion Picture and Television Engineers (Berkeley, CA: University of California Press, 1967), 52.

importance has been minimized. The question is not posed, for example, why researchers at the time preferred additive synthesis, a quite interesting epistemological question. One way to think about this point would be to examine the role of James Clerk Maxwell's founding experiment, described in 1855 and carried out in 1861, which demonstrated that the possibility of three-colour synthesis using an experimental *dispositif* joining photography and projection[10] – thereby playing, once again, on the reversibility of the projection mode of photography. Maxwell's experiment appeared a suitable application for and easily adaptable to cinema at a time – before the Lumière autochrome, which was introduced to the market in 1907 – when colour photography had not yet taken hold in a concrete industrial manner.

But the historiography barely develops the theoretical implications of the procedure's specificities either. In George Albert Smith's patent application, these consisted in the combination of two elements: 'the use of two colours only, red and green, combined with the principle of persistence of vision.'[11] Kinemacolor was thus a two-colour process, which in itself would have major consequences. Authors of the day discussing the validity of this two-colour nature – in light of the images they had seen and by measuring them against other colour procedures, such as stencilling – would employ a discourse in which *realism and indexicality were in opposition*,[12] a rare theoretical event.

The other specificity of the *dispositif* is also fascinating. Kinemacolor projected in succession, at high speed, a red image and then a green image. George Albert Smith was counting on the same principle of perception, 'persistence of vision', to create *both* and *at the same time* colour synthesis and the synthesis of movement – an idea, we might recall, already formulated by Charles Cros. Here, the interval between two photograms supported

10 James Clerk Maxwell, 'Experiments on Colour as Perceived by the Eye, with Remarks on Colour-Blindness' (1855), *Transactions of the Royal Society of Edinburgh* 21, no. 2 (1857): 275-298. See also Richard C. Dougal, Clive A. Greated and Alan E. Marson, 'Then and Now: James Clerk Maxwell and Colour', *Optics and Laser Technology* 38 (2006): 210-218. Maxwell's *problem* was not at all colour photography, but rather the experimental demonstration of Thomas Young's hypothesis concerning the existence of receptors sensitive to the three primary colours in the human retina. See this other fundamental text: Thomas Young, 'On the Theory of Light and Colours', *Philosophical Transactions of the Royal Society of London* 92 (1802): 12-48.

11 George Albert Smith, British patent no. 26,671.

12 On this topic I take the liberty of referring the reader to my article 'Le Naturel et le mécanique: le Kinemacolor à la conquête de Paris, ou Charles Urban *vs.* Charles Pathé', *1895 revue d'histoire du cinéma* 71 (Winter 2013). Eirik Frisvold Hanssen has also explored this question somewhat in his Ph.D. dissertation *Early Discourses on Colour and Cinema* (Stockholm: Stockholm University Press, 2006), in which he raises Kinemacolor on several occasions, on the basis in particular of the 1912 film catalogue, but does not explore the technical aspect of the procedure.

simultaneously movement information and colour information. Movement and colour are thus made equivalent, in a sense, by the procedure – an equivalence that Colin N. Bennett had already suggested in his comment quoted above. And both were viewed as possibly being a part of the same fundamental perceptive phenomenon, the 'persistence of vision', supposedly capable of carrying out the two synthesis operations in question.

The Kinemacolor principle meant that the colour analysis (in the film shoot) and colour synthesis (in projection) were accomplished through two *successive* colour selections. For the colours to merge, it was crucial that the two images of 'colour sensations', as one expression of the day had it, be superimposed perfectly. This procedure, like other additive synthesis systems at the time, also brought about a disjunction: a photogram was no longer a 'complete' image. Two successive photograms had to be synthesized in order to obtain something like an 'elementary image'. This is why there could be no 'stop frame' in Kinemacolor.[13]

The first limit to 'perfecting' superimposition was that of the mechanical precision of the cameras and projectors: the slightest wobble, meaning the slightest disjunction in the position between one photogram and the next on the film stock, would give rise to a disjunction between the red and green images on screen. As a 1909 review of the inaugural projection at the Palace Theatre in the British trade paper *The Bioscope* remarked, 'there are blinding flashes of red or green across the entire picture.'[14] This was due, and this comparison was made systematically in commentary of the day, to the printers being 'out of register,' meaning that the coloured layers were not in synch: the colours would spill over. In film equipment, steadiness is directly proportional to the quality of the mechanical workings and thus to the price of the machines. This is one reason why the 1910 catalogue for Kinemacolor materials was resolutely 'high end.'

In this way, the Kinemacolor procedure – its very viability, but also the frequency with which its 'defects' were pointed out by commentators – informs us today on the state of technics around 1910, a moment in the history of cinematic perception that machines determined and of which they are the archive: greater or lesser steadiness; jumping, flicker, complaints of vision fatigue, etc. It also informs us, finally, what film viewers *saw* in 1910, or the way in which they saw.

13 The case of Gaumont's Chronochrome (or Gaumontcolor) was different yet again: it was a three-colour additive process, with simultaneous rather than successive coloured sections. There was thus a scission of the 'elementary image' into three photograms, but because these three photograms could be projected together it was possible to carry out a stop frame.

14 Anonymous, 'The Kinemacolor Pictures', *The Bioscope*, 4 March 1909, 23.

The second limitation to the perfection of superimposition was extreme and insurmountable. Because the two coloured selections were successive, they were out of synch with the time of the take. Thus, any moving object would not have the exact same position in the image between the green and red selection; this, in the technical literature on the topic, is called 'temporal parallax.' As Jacques Ducom wrote in 1913,

> When rapid movements are recorded, the two images of Kinemacolor's coloured pairs can be sufficiently dissimilar for every element of these images not to be superimposed completely on the screen. A part of the projected image: an arm, a leg or an automobile, for example, can be predominantly red or green.[15]

'The projection of the moving objects,' John B. Rathburn wrote in 1914, 'results in a disagreeable flicker.'[16] According to the 'opérateur cinégraphiste' Chevreau, writing in *La Cinématographie française: Tecnhique et matériel* in 1936, 'the projection was spoiled';[17] or, as Herbert Kalmus disdainfully summed up in 1938, 'it was nothing for a horse to have two tails, one red and one green.'[18]

These coloured fringes were Kinemacolor's major defect, a 'disconcerting feature' that, as the British author Frederick A. Talbot wrote in 1912, 'the most uninitiated observer cannot fail to see': it 'has aroused considerable comment' and, 'although it is often momentary, it is decidedly distressing.'[19]

For the entrepreneur Charles Urban, these fringes were a major inconvenience. From another perspective, they also made Kinemacolor a truly experimental *dispositif* in the way it transformed the gaze; each film being read, as André Gunthert has written, as 'a technological monument capable of being interrogated archaeologically.' What these fringes fleetingly gave

15 Jacques Ducom, 'Les procédés de cinématographie en couleurs naturelles: Le Kinemacolor et le nouvel appareil des établissements Gaumont', *L'Industrie cinématographique* 2, no. 3 (15 January 1913): 73.
16 John B. Rathburn, *Motion Picture Making and Exhibiting* (Chicago, IL: Charles C. Thompson, 1914), 219.
17 Chevreau, 'La Couleur. Résumé par un praticien. Quel est le procédé qui conviendra au marché français?', *La Cinématographie française: Technique et matériel* 939 (31 October 1936): 1.
18 Herbert T. Kalmus, 'Technicolor Adventures in Cinemaland', 52.
19 Frederick A. Talbot, *Moving Pictures: How They Are Made and Worked* (London: William Heinemann, 1912), 298.

material form was the gap in the position of a moving body between two photograms – or, to borrow Dziga Vertov's expression, the *interval of movement*. These fringes show, *in colour*, the *quantity of movement* separating two images in the cinema – and they do so at 32 images per second, depicting a shorter interval than the usual speeds of the day or today, from fifteen to 24 images per second. These coloured fringes showed what, in the cinematic mechanism, was constantly threatening to break up the *image-movement*: the presence, underneath, of a series of fixed flickering images. And the procedure demonstrates that even for 'the most uninitiated observer,' the interval of movement is not really an abstraction, it is *perceptible*.

This is exactly what an artist such as Paul Sharits later sought to bring out, in particular in his 1975 installation *Shutter Interface*, in which four projectors simultaneously play coloured loops of varying lengths, the images being partially superimposed on screen. For Sharits, the constant coloured flickering and transformations of the hues, through additive synthesis, should make the viewer *see* the activity of the shutter, should show what happens in the interval between images, and show that we see it. This is something that Kinemacolor had already accomplished.

The Cinema According to Charles Urban

While Smith was the inventor of the Kinemacolor procedure in the technical sense, in fact Charles Urban was its midwife and the person who gave it coherence. The American-born Urban was another central figure in early British cinema. On many points, he was a character of the same stamp as someone such as Charles Pathé in France: a talented and ambitious businessman, who, in just a few years, rose to the top of this nascent industry. But his conception of cinema, its nature and place in society, its function, and the ways one could make one's fortune in it, were, interestingly, radically different from those of Pathé.

Indeed, Charles Urban had conceived a very precise idea of cinema. I will not explore this figure and his ideas here in all their complexity, even though he certainly merits closer examination.[20] Urban arrived in the United Kingdom in 1897 and, for a time, led the English branch of Maguire

20 See in particular the work of Luke McKernan: *'Something More than a Mere Picture Show'*; and his editions of Urban's writings: Luke McKernan, ed., *A Yank in Britain: The Lost Memoirs of Charles Urban, Film Pioneer* (Hastings: The Projection Box, 1999). See also Charles Urban, 'Terse History of Natural Colour Kinematography', *Living Pictures* 2, no. 2 (2003): 59-68.

and Baucus, in charge of the distribution of Edison films in Europe. There, he worked with Cecil Hepworth. In 1898, he became director of the Warwick Trading Company, which he left in February 1903 to found the Charles Urban Trading Company in July of that year, along with Alfred Darling and George Albert Smith. During this period, Urban tasked Smith with developing a colour film procedure on the basis of a patent that he had purchased in 1902: the Lee and Turner patent, filed in 1899, for a three-colour process that had not got beyond the experimental stage. The year Smith completed his research, 1906, Urban founded the firm Éclipse in France, from which he resigned in November 1909.

This seemingly eventful if not chaotic professional itinerary (and I have far from outlined every contour, moment of turbulence, and reversal) was curiously compensated for or influenced by a clear guiding principle. Fiction, for Urban, held very little interest. In his memoirs, which McKernan reports were written shortly before his death in 1942, he recounts his initial admiration for the quality of the Lumière machines and *productions*: 'The Lumière company of Lyons France could not be induced to sell their cameras, projectors or films. The Lumière product was the best shown [...]. Their photographic quality and selection of subjects were superior to any of the others obtainable'.[21]

In a sense, the Lumière model would remain fundamental for Urban. As soon as he began to acquire a little more independence, he focused on the production of 'non-fiction' films: travel, education, science, actualities, etc. In 1907, Urban, who had just been nominated to the Zoological Society for his popularizing work, published with his own Charles Urban Trading Company a book entitled *The Cinematograph in Science, Education, and Matters of State* – here, the adoption of the term 'Cinematograph' in English may be indicative of the suggestion of a line of descent beginning with Lumière, although no such connection is discussed in the book. The first section of the book bears this statement as its title: 'The Cinematograph Demands National Recognition'.[22] Before exploring the possible uses of the cinematograph in the various fields named in the title of his book, Urban sets out his policy:

> The entertainer has hitherto monopolized the Cinematograph for exhibition purposes, but movement in more serious directions has become imperative, and the object of this pamphlet is to prove that the

21 Charles Urban, *A Yank in Britain*, 48.

22 'The Cinematograph Demands National Recognition', in Charles Urban, *The Cinematograph in Science, Education, and Matters of State* (London: Charles Urban Trading Company, 1907), 7.

> Cinematograph must be recognized as a National Instrument by the Boards of Agriculture, Education, and Trade, by the War Council, Admiralty, Medical Associations, and every Institution of Training, Teaching, Demonstration and Research.[23]

From the point of view of dominant contemporary historiography, Urban's position may seem strange to say the least, if not untenable: Urban adopted a position opposed to entertainment and, more broadly, to fiction from within an extremely commercial enterprise. Whereas his commercial energy, entrepreneurial spirit, and flair for promotion made Urban similar to the great entrepreneurs of the nascent industry, his discourse situated him closer to Bolesław Matuszewski's *Animated Photography, What It Is, What It Should Be* (1898) and to the later production policy developed and theorized by John Grierson for large state bodies in England and Canada.[24] The specificity of Urban's project was to believe in the *commercial* potential of such a position: from this perspective, his strategy was perfectly consistent with and based on giving legitimacy to cinema in the eyes of his 'target audience', the leisure classes then largely absent from cinema halls, whom others at that same time also wanted to win over on the basis of very different principles, those of fiction, through the 'Film d'Art'. Noël Burch has pointed out that after reviewing the first Lumière projection in England in 1896, the daily newspaper *The Times* would not mention moving pictures at all in its columns for many years:

> In fact *The Times* did not mention the cinema in its own right until 1906, when the American producer-distributor Charles Urban, a specialist in 'actualities' (the only genre to find favour with the middle classes in Britain, too), invited the press to a showing of views – in particular a bull fight filmed in Spain – which he had thought it ill-advised to screen for wider audiences. Whereupon the *Times* columnist naturally congratulated him for this act of paternalistic self-censorship.[25]

23 Ibid. Note that the term 'Cinematograph' here, even with an initial capital 'C' as it appears in the original, is not a reference to the Lumière device alone, as the word 'Cinématographe' would suggest in French.

24 See Bolesław Matuszewski, *A New Source of History: Animated Photography, What It Is, What It Should Be* (1898) (Warsaw: Filmoteka Narodowa, 1999); Forsyth Hardy, ed., *Grierson on Documentary* (London: Faber and Faber, 1979); and Caroline Zéau, 'Cinéaste ou propagandiste? John Grierson et "l'idée documentaire"', *1895 revue d'histoire du cinéma* 55 (June 2008): 52-74.

25 Noël Burch, *Life to Those Shadows*, 97.

The seeming austerity involved in the rejection of fiction was not only the pure virtue of devotion to public causes, to the disinterested discovery of the world and the sciences; it was also a clear and conscious economic strategy. But whatever happened financially to his business dealings, Urban never abandoned these fundamental principles respecting 'animated photography, what it is, what it should be' – principles or fundamental belief in a certain future for kinematography.

This is the context in which the project and realization of what would become 'Kinemacolor' must be understood. In 1902, Urban purchased the patent filed in 1899 by the Englishmen F. Marshall Lee and Edward R. Turner[26] for a procedure making it possible to 'produce kinematographic pictures in such manner that they may be exhibited in the colors of the originals'[27] – a procedure that, in fact, did not work. But Urban nevertheless believed in the system enough, or had a sufficiently strong wish for a kinematographic system in 'natural colours,' to finance four years of research by Turner and later by Smith.

Technics and the Commercial

Compatibility and Specialization

From a technical and commercial perspective, the Kinemacolor procedure as designed enjoyed a number of interesting advantages. Firstly, it worked with traditional black-and-white film, which needed only an initial panchromatizing treatment for it to be made sensitive to red. This treatment was somewhat onerous but not problematic. Next, Kinemacolor could be projected using a traditional projector, as long as it underwent relatively minor modifications: the speed had to be doubled – but when projectors of the day were motorized, the motors always had a rheostat, giving them variable speed, even though that naturally caused greater wear on the machine and the film stock; and the shutter had to be transformed, or a synchronous rotary colour filter added – but projectors of the day always had an immediately accessible external shutter that could be modified very easily.

26 British patent no. 6,202, 22 March 1899; United States patent no. 645,477, filed 14 October 1899.

27 Frederick Marshall Lee and Edward Raymond Turner, United States patent no. 645,477, first page.

This was a crucial argument: exhibitors would not need to change their equipment, they would not need to specialize in the projection of colour films[28] – they could show both, even as part of the same screening. The programme of the inaugural Kinemacolor screening at London's Palace Theatre on 26 February 1909 had already demonstrated this possibility. *Sweet Flowers*, the tenth film on the programme, shown immediately after the intermission, was advertised as having to be shown twice:

> This picture will first be shown as an ordinary Black and White Bioscope view. After an interval of two seconds for adjusting Colour Filters to the Urban Bioscope Machine, *this same picture* will be shown in its natural hues and tints.[29]

Two seconds must have been slightly optimistic, and it would be interesting to know what it would look like to present a film recorded in Kinemacolor and projected in black-and-white at 32 frames per second, whose even-numbered photograms had different densities from its odd-numbered ones. In any event, this practice made clear the performative and experimental dimension of a Kinemacolor screening, just as the insistence on the speed with which the transition could be carried out indicated the *dispositif*'s ease of use and its adaptability to existing systems.

This compatibility, Smith remarked in 1908, had been adopted from the outset of his research as a fundamental condition of what would become his *dispositif*. After having set out the technical indications for accomplishing the effect itself, he added the presence of another constraint:

> To conform to the condition that any scheme must be easily applicable to the existing cinematograph machinery, and that the standard film with standard perforations must be used, so that any successful results might be readily adopted by every cinematograph user without much trouble or expense.[30]

28 This would be the case, however, for the Gaumont Chronochrome system.

29 *The Palace Theatre of Varieties. Friday, February 26th, 1909, at 3 p.m. Special Invitation Matinée. The First Presentation of 'Kinemacolor'. Urban-Smith Natural Colour Kinematography* (*Animated Scenes and Moving Objects Bioscoped in the Actual Tints of Nature*) (programme). Reprinted in D.B. Thomas, *The First Colour Motion Pictures* (London: Her Majesty's Stationery Office, 1969), 18. Emphasis in the original. The capital letters found in the original have been preserved here, as well as the term 'Bioscope', still a rival term at the time on England with those terms derived from the term 'cinématographe' adopted in France.

30 George Albert Smith, 'Animated Photographs in Natural Colours', *Journal of the Royal Society of Arts* 57 (11 December 1908): 73.

These remarks tend to again contradict the idea that technical research took place in two stages, at first 'pure' and endeavouring solely to obtain the 'satisfactory result', and then adapting this result to practical use. The conditions of possible future use, and thus industrial and commercial policy decisions, came into play in establishing the conceptual framework of the investigations. In the almost contemporaneous research that led to Chronochrome, the Gaumont company would not set this limit on itself.

Whereas Smith held to this line, and Kinemcolor was indeed adaptable to a traditional projector, Urban would nevertheless – by necessity or by choice – produce special, better adapted machinery, and his Natural Colour Kinematograph Company began to sell not only films, but also Kinemacolor equipment: cameras; projectors (Illus. 47); and coloured filters, along with lanterns for projecting still images, motors, rheostats, control panels, etc. Kinemacolor, in the process of being institutionalized, became a complete technical network and, as a result, its users (exhibitors, operators) had to have all the necessary parts. In 1969, D.B. Thomas summed up this evolution to specific equipment designed by Urban's historical collaborator Henry W. Joy and introduced in March 1910:

> During 1909 Kinemacolor projectors were made by fitting the rotating colour disc shutter to an ordinary Urban bioscope projector and running it at double speed. This was an unsatisfactory arrangement and resulted in excessive wear on the film [...]. The Kinemacolor projector was heavier and more substantially built than conventional machines to reduce vibrations which would otherwise occur during the double speed operation.[31]

The technical need for sturdy projectors was perfectly suited to Urban's commercial project and enabled him to play resolutely the 'high-end' card towards both exhibitors and audiences. Or, as the introduction to the equipment catalogue published in 1910 by the Natural Colour Kinematograph Company described it, the 'highest plane of bioscopic excellence.'[32]

31 D.B. Thomas, *The First Colour Motion Pictures*, 19-20. It is still the wearing out of the celluloid and the perforations which is in question here.

32 *The Glories of Nature Permanently Recorded by the Action of Light Only: Handbook of Cameras, Projectors and Appliances for Reproducing and Perpetuating the World's Events in Natural Colors* (London: The Natural Color Kinematograph Co., 1910), 5.

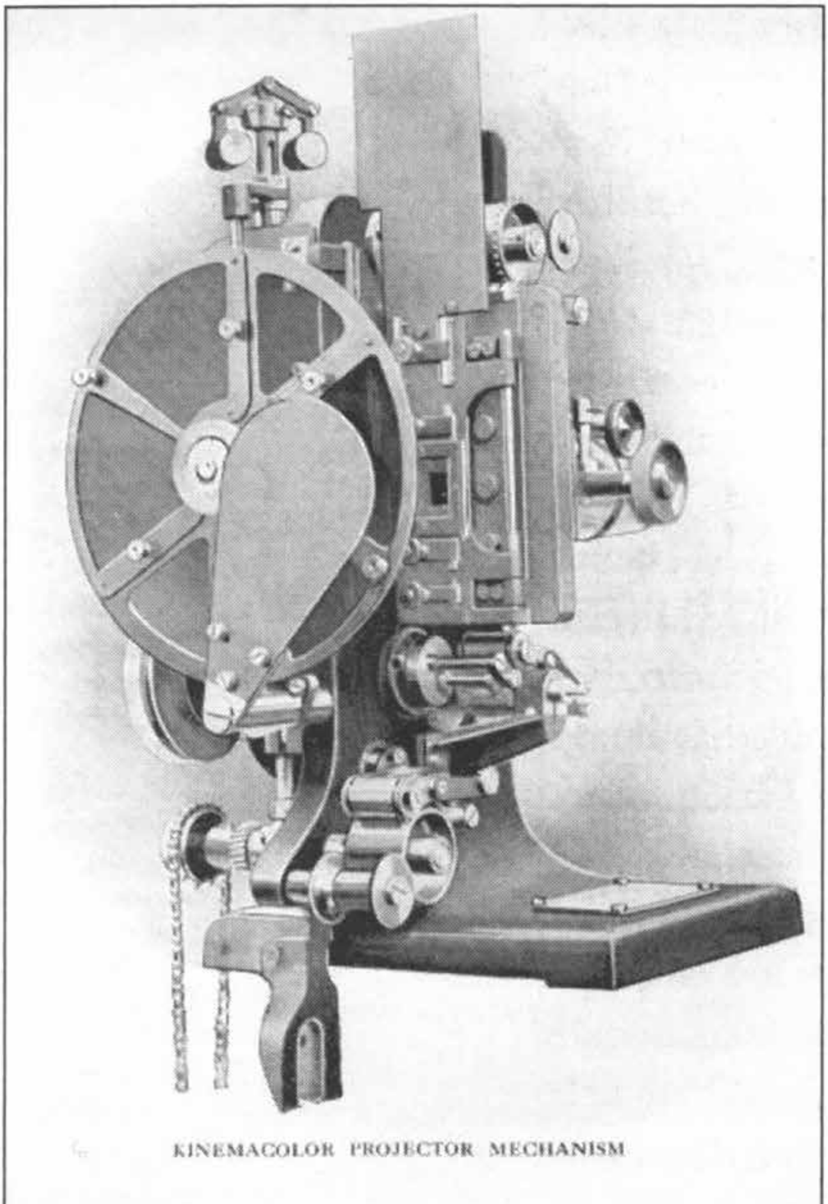


Illustration 47 – Kinemacolor projector. From B.E. Jones, How to Make and Operate Moving Pictures (Funk & Wagnalls, 1917).

Constraints or Coherence

For taking pictures, the Kinemacolor machine was not complicated to use, but it did have its own constraints. Firstly, the faster speed meant that twice as much film was used, and thus higher production costs, more frequent magazine changes for the operator, and an exposure time of half the length for each photogram. In addition, the green and red filters between the camera lens and the film (Illus. 48) absorbed a considerable amount of light. Kinemacolor thus required favourable if not exceptional lighting conditions, meaning a sunny outdoor location.[33] In practice, it was virtually impossible to shoot in a studio.[34]

This constraint may appear quite strong, as it prevented the shooting of scenes with the usual technical materials without coming up with complex and costly adaptations specific to the situation. But here again we see the coherence of Urban's project: this concrete limitation of the *dispositif* was not a major problem, his project having always been to make documentary type pictures. As he wrote in 1910,

> With the life and scenery of the world, in every land upon which the sun shines, waiting to be recorded in color, time spent in finding ways and means of photographing artificial comedies or artificial tragedies by artificial light is wasted.[35]

It was indeed necessary that the sun shine in these countries, but as we all know, the sun never sets on the British Empire.

Although George Albert Smith was certainly the sole inventor of Kinemacolor from a 'strictly technical' point of view, the procedure found its coherence in the overall logic of Charles Urban's commercial and aesthetic project. For Urban, 'natural colours' were not a supplement to, but rather an achievement; colour was not an advance, a form of 'progress', an 'innovation', but a return. Commenting in the programme of the inaugural screening on 26 February 1909, Luke KcKernan remarks:

33 This problem of excessive light absorption is found symmetrically in projection, leading to reduced luminosity of the images or to the need to compensate for this with a strong lamp.

34 D.B. Thomas remarks that '[f]ilm studios were increasingly using artificial lighting to replace and supplement natural light, and after 1912 the artificial light was often the Cooper-Hewitt mercury vapour lamp introduced from America. This was particularly strong in blue-violet light and very weak in red and green; quite suitable for black and white filming but useless for Kinemacolor or any other colour process'. (*The First Colour Motion Pictures*, 31.)

35 Quoted by D.B. Thomas, ibid.

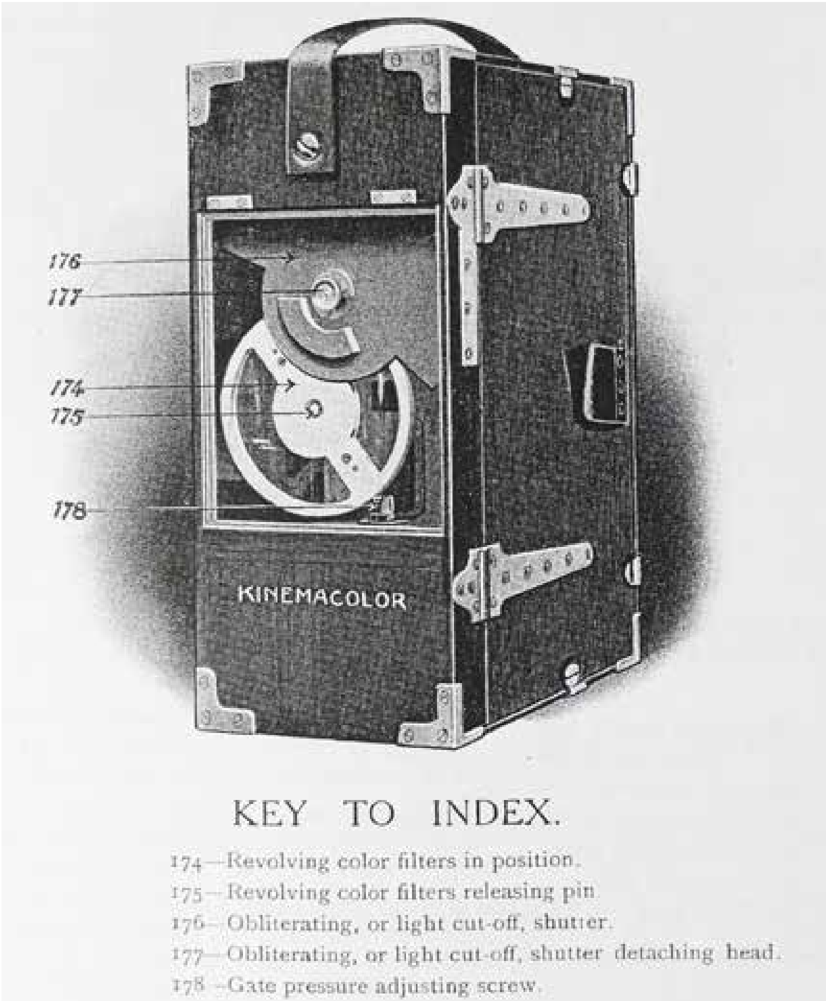


Illustration 48 – Kinemacolor camera. Catalogue, 1910.

> With its parades, scenic views, quaint animals and even that oldest of film subjects, waves breaking on the shore, the first Kinemacolor programme reads like a Lumière programme of 1896, certainly a rejection of cinema as diversionary entertainment [...]. Urban was reinventing cinema.[36]

It was thus not a question of giving colour to films as they were being produced by the nascent industry – this, for example, was the goal of

36 Luke McKernan, '*Something More*', 132-133.

Technicolor – but to overthrow an industry that had got off on the wrong foot, to return to the sources of kinematography as could be seen in the Lumières' project, and thus to win over (win back) a finally worthy audience. A similar idea ran through the firm Pathé at the time, as Laurent Le Forestier points out: 'From 1906 to 1910, shooting outdoors became […] a veritable aesthetic desire, something necessary to win over a broader audience, which appeared to be clamouring for this association of cinema with reality'.[37]

Pathé's strategy to win over this 'broader' (and 'improved') audience had partially similar bases but was diametrically opposed to Urban's. Naturally, Urban could not reproduce the Lumières' 'coup' exactly: fifteen years later, screen practices had changed too profoundly, the context had been too altered. But this was where the idea lay: to erase this period of history and start over. And Urban's situation is revelatory of a moment of possible hesitation of the industry and of film as medium and media, between fiction, spectacle, and entertainment on the one hand and science, document, and reality on the other: between applied colours and natural colours.

In her book on the history of American cinema, Eileen Bowser described the position of the Kinemacolor Company of America, the producer and distributor of Kinemacolor films in the United States, as follows:

> The special place that American Kinemacolor occupied in the industry is signalled by the fact that the reviews in the trade papers were divided into three groups: the licensed, the independent, and the Kinemacolor productions. The *New York Dramatic Mirror* sometimes carried news of Kinemacolor in its theatrical section instead of in the moving-pictures section. Kinemacolor was important to the cause of uplifting the industry and attracting a middle-class audience. Operating outside the organized distribution system of the movie theatres, it carried special prestige […] it played in legitimate theatres, auditoriums, opera houses, and similar high-class venues.[38]

37 Laurent Le Forestier, 'Une disparition ins*truc*tive: Quelques hypothèses sur l'évolution des "scènes à trucs" chez Pathé', *1895 revue d'histoire du cinéma* 27 (September 1999), 70. Le Forestier, drawing in particular on a text by Roland Cosandey, shows the existence at the time of a '"battle" between the spectacular and the real' (p. 71) with respect to trick scenes. We might wonder what role in this opposition was played by colour, whether 'natural' or artificial.

38 Eileen Bowser, *The Transformation of Cinema 1907-1915* (New York: Charles Scribner's Sons, 1990), 228.

Kinemacolor stood quite radically apart from film production as a whole, even though the Kinemacolor Company of America, an independent company founded in April 1910,[39] had its own production policy, which was much less hostile to fiction than was Urban's Natural Colour Kinematograph Company. Bowser also demonstrates that Kinemacolor's central contribution to film history may be due at least as much to this 'prestige' tied to its production policy, its promotional strategy, and to its modes of distribution as to its technical progress properly speaking with respect to colour. For there was no inherent cultural prestige associated with colour – later, dominant cinema would even appear to reserve its use for spectacular and thus 'popular' films[40] – even though the 'Film d'Art' also appeared in this era of colour films.

It appears that there was a moment when Kinemacolor represented precisely a kind of 'apotheosis of the kinematograph': a luxury version with a somewhat austere sense of good taste miles from the usual film capers, a version of cinema legitimized independently of cinema as a whole by the cultured upper-middle classes, a version capable of pleasing at one and the same time 'artistic and elegant persons of distinction', children and royalty, Kinemacolor was both a little outside of cinema and, at the same time, its very essence.

The Kinemacolor procedure appeared at a time of profound upheavals in the field – what some historians have described as the passage from early cinema to a transitional period. Modes of exhibition, the economic structure, the way screenings were organized, film form, and the medium's role in society were all undergoing great changes. This moment was a historical crux, an intersection from which several paths appeared possible for the medium. Nothing about the time was simple or linear. While Urban may appear to be a 'pioneer' or a 'precursor' for choosing 'natural colours', something history would enshrine many years later, his rejection of fiction and entertainment

39 On the Kinemacolor Company of America, see Luke McKernan, '*Something More*', 165-170; and Gorham Kindem, 'The Demise of Kinemacolor: Technological, Legal, Economic, and Aesthetic Problems in Early Color Cinema History', *Cinema Journal* 20, no. 2 (Spring 1981): 9-12. Kinemacolor's distribution policy outside the United Kingdom, developed by Urban, was based on the sale of rights to already existing or specially created local firms, with which Urban may or may not have had financial ties. This model caused him a lot of problems in France and the United States, in particular because of the loss of control it involved. The complex implications of this deserve to be explored separately on the basis of detailed, concrete study of each case, something that remains to be done.

40 See Steve Neale, *Cinema and Technology: Image, Sound, Colour* (London: Macmillan, 1985), 145-158.

made him out of synch with the dominant current – even though, by virtue of this very fact of being out of synch, he contributed, albeit in a singular fashion, to the task of culturally legitimizing the cinema, one of the great tasks of the day. But 'progressive' Kinemacolor ran aground in 1914-1915 even though other colour film procedures – 'applied' colours: coloured by hand or stencil, at first manually and then mechanically, tinted, toned, and systems combining these – would continue to be used until the late 1920s.

The reasons for this failure of a procedure that had met with overwhelming success are of keen interest to commentators. Were these reasons mostly technical in nature? Economic? Aesthetic? Legal? Corporate?[41] Did they have to do with the fringes of the two-colour system, with the need to change the projection equipment, with the price of admission, with a production policy founded on the rejection of fiction, or, more broadly, with the rejection of what cinema had become in the first decade of the twentieth century?

What is striking most of all, as I hope to have shown here, is the degree to which the Kinemacolor system was coherent. Taken in isolation, the 'natural colours' procedure invented by George Albert Smith had visible limitations and sometimes astonishing qualities, while involving relatively major constraints. But it was never thought of in isolation: from the outset, it was part of an overall project developed by Charles Urban, in which the technical procedure was employed in a certain manner in order to produce certain films, promoted with certain arguments, shown in certain kinds of venues, and made for a certain kind of audience.

Kinemacolor thus formed a specific technical network: cameras; projectors; coloured filters; venues; patents and licences, etc. But its homogeneity came only from its clearly established and equally specific production, promotion and dissemination policies. Its absolute coherence of machines and discourses, its technical, aesthetic, political, and commercial conceptions, made Kinemacolor a true system in the strongest sense of the term. This coherence was the strength of Urban's project, in which colour, and 'natural colours' precisely, played a decisive role. But it may also have been its weakness, or what Gilbert Simondon would have called its 'residual abstraction',[42] preventing it from taking concrete form on a large industrial scale. This coherence was contradicted, for example, by Urban's decision to leave management of the procedure abroad to autonomous firms purchasing a local patent: it would be only a slight exaggeration to say that only Urban

41 See Gorham Kindem, 'The Demise of Kinemacolor', 3-14.

42 'Every technical object has residual aspects of abstraction'. Gilbert Simondon, *On the Mode of Existence of Technical Objects*, 51.

saw the consistency of the whole in each element of the *dispositif*, making any loss of control disastrous. While Smith was the inventor of the procedure, it was Urban who can be seen as the inventor of Kinemacolor as a technical and conceptual network.

This cohesion can be seen not only in the procedure itself, as an autonomous entity: it applies to the entire historical context in which it was conceived and in which it was used. Rapid transformations of the context could only interfere with Kinemacolor's internal cohesion, bringing about reconfigurations, dispositions, and evolutions. The solid connections between the *dispositif*'s elements then prevented these modifications to the general architecture. The weakness and, ultimately, the ruin of the Kinemacolor system was its very solidity. But this compactness, the networks of adherences with all of cinema of the day it brought about, and the technical, aesthetic, economic, and perceptual originality of its set-up are also what makes it of special interest today and what gives its archaeology such fertile potential.

6. Epilogue

From the Trembling of Film to the Stability of the Digital

Abstract

This last part returns to a consideration of the problems connected with the digital turn. Here, the focus is initially on the perceptual characteristics of early cinema. As in Kinemacolor, the 'defects' – the trembling of the cinema image – are not overlooked as minor temporary technical problems, but as major specificities that came to define the medium. Traditional cinema is thus read as belonging to the episteme of the mechanical, where trembling is connected with machines, themselves always moving. 'Digital cinema', as a stable medium, thus appears as a result not only of a technological shift, but of an epistemological one.

Keywords: Trembling, modernity, perception, digital cinema, digital technology, media history.

In 1995, in a text that, not at all by chance, addressed the question of colour, Georges Roque remarked that 'we have undoubtedly not fully grasped the importance that the concept of movement took on for both science and art beginning in the 1880s.'[1]

Naturally, this could only be a statement in hindsight; for people of the day, it was not so much the concept of movement that had the importance described here, but rather movement itself. It was not a change of paradigms; it was a transformation of the world. This suddenly manifest presence of movement was certainly connected, as has frequently been noted,[2] with the rapid evolution of the means of transport in the early twentieth century – automobiles, trains, planes, streetcars, subways – which completely redrew the body's relations with physical and geographic space and created hitherto unseen situations of perception. The latter were not only unprecedented in

1 Georges Roque, 'La Couleur: simultanée et successive', *Fotogenia* 1 (1995): 310.

2 See for example Annemone Ligensa and Klaus Kreimeier, eds., *Film 1900: Technology, Perception, Culture* (New Barnet: John Libbey, 2009).

Turquety, B., *Inventing Cinema: Machines, Gestures, and Media History*. Amsterdam: Amsterdam University Press, 2019.
DOI 10.5117/9789463724623_CH06

their regular and passive high-speed conveyance through the landscape, these conveyances also effected – more so than today – a singular kind of jolting, trembling, and shaking of the entire body and thus also the eyes. The connection between these modes of transportation and the cinema was obvious at the time on this point as well, as Jules Claretie remarked, for example, in 1896:

> I don't know which physiologist declared that the railways, with their shaking, would in the end displace human brains. Too many big and little jolts [...]. The jolts of the railways are minor, however, compared to those which impress on the brains of our contemporaries the surprises, dramatic effects and clanging of our extraordinary existence [...]. And how could we not be perturbed by the agitated kinematograph which modern life has become, in which characters appear and disappear after an aggravated dumb show, punctuated by electric flashes and scintillation?[3]

'All these jolts', as Claretie wrote, are modernity itself, running through people's bodies and minds. The pleasure of the 'displacement of the brain' would moreover be played out again beginning in 1906 with George C. Hale's 'Pleasure Railway' – film screening rooms in which pictures taken from trains were shown while viewers' seats were shaken.[4] Here, one's belly had to be shaken as much as one's eyes, for beyond the change of location shakiness is the essence of transportation as a moment of perception. The difference between displacement and movement thus lies in shakiness and jolting; this is a major difference, echoes of which can be found in the ideas of Henri Bergson – whose exactly contemporaneous book *Creative Evolution* connects the kinematographic mechanism to the kaleidoscope because of the shared principle of *jolts*.

Although movement was ubiquitous in the early twentieth century, it was not wholly due to the railway. For what is at issue is not solely an acceleration of transportation, but a heightened sensitivity to the general movement of things. This upheaval affected both perception and conception, which it inextricably linked. The world was stable, as was the simple contrast between

3 Jules Claretie, *La Vie à Paris: 1897* (Paris: Bibliothèque-Charpentier, Eugène Fasquelle, 1898), 416-417. Quoted by François Albera in '"L'école comique française", une avant-garde posthume?', *1895 revue d'histoire du cinéma* 61 (September 2010): 84.

4 See Raymond Fielding, 'Hale's Tours: Ultrarealism in the Pre-1910 Motion Picture', *Cinema Journal* 10, no. 1 (Autumn 1970): 34-47.

solids at rest and mobile objects traversing space. Suddenly, movement was everywhere and in everything: an inexhaustible movement, dizzying, infinite, and infinitely scattered. Movement was no longer simply in the world; the entire world itself was movement. The history of this awareness is precisely that of the introductory chapter added in 1909 to the definitive edition of Camille Flammarion's *Contemplations scientifiques*, which had been published in various forms since 1870 and which would be reprinted until 1930. This new chapter was entitled 'Le Mouvement dans la nature'. In it, the narrator begins by describing himself 'seated in the shadow of fragrant pines and scented eucalyptus' in a nature 'in the full and calm intensity of springtime harmony.' But nothing lasts in this world:

> Suddenly, in this calm contemplation, a keen image ran through my brain. I saw myself being carried along on an automobile hurtled inexorably into the abyss at a fantastic speed of 106,800 kilometres per hour!
> And suddenly also, this image instantly replaced the first image and replaced the seeming tranquility of the world through the sensation of formidable labour about which no one thinks.[5]

With this dual 'suddenly' of an abrupt image substitution, the 'scientific contemplator' experiences the vertiginous intrusion of the real: the Earth is only an automobile. More specifically: 'Everything is in movement. Everything is movement. And it is even impossible for us to take in the real speeds, because our measurements all refer to the moving points themselves'.[6]

We are thus caught in an immense movement, one infinitely compound and complex, without the slightest fixed point. But this formidable cosmic race is overtaken by yet more shocks, hidden in the depths of the living, for

5 Camille Flammarion, *Contemplations scientifiques* (Paris: Ernest Flammarion, n.d.) (According to Danielle Chaperon: *Contemplations scientifiques, la nature, l'homme, les animaux* (Hachette, first series 1870, second series 1887, definitive edition in one volume, Ernest Flammarion, 1909, p. 2.)

6 Ibid., 5. G.-Michel Coissac opens the first chapter of part two of his *Histoire du cinématographe*, entitled 'Principes généraux du cinématographe', with a few paragraphs which uncannily echo these phrases, while placing them in the framework of Marey's work: 'Everything in nature is movement: perceptible movements, if they are quick; imperceptible movements, barely grasped, if they are slow (the growth of animals and plants, the expansion of bodies, the disintegration of rocks, chemical phenomena); unsuspected by many, if they do not impress our senses (intense movements within matter said to be inert and within the atom itself). We can thus understand that human ambition has been to reproduce these movements exactly'. (G-Michel Coissac, *Histoire du cinématographe*, 155.) Coissac's conclusion, which generalizes and ahistoricizes a perception that was born in this era, is familiar to us.

example those of springtime, when 'the Earth is embellished with flowers, the air is scented with a thousand fragrances; every being *quivers with a mysterious vibration* and prepares for the task of reproduction.'[7]

This quivering of everything, resulting in an eroticization in which the gaze and the body, contemplation and desire, are intertwined, is profoundly a discovery of the nineteenth century. From Augustin Fresnel, Thomas Young, and James Clerk Maxwell exploring the wave structure of light in the first decade of the century and Charles Wheatstone and Jules Antoine Lissajous visualizing sound waves a few years later, to the wave mechanics developed out of the work of Louis de Broglie in the 1920s, science has constantly given ever more extreme expression to a definition of the world as pure vibration. Culture did not remain far behind, and this final phrase of Flammarion's cannot help but remind us of the famous chapter on colour in the 'Salon of 1846', which, even then, Baudelaire opened with a form of 'scientific contemplation':

> Let us suppose a beautiful expanse of nature, where there is full licence for everything to be as green, red, dusty or iridescent as it wishes; where all things, variously coloured in accordance with their molecular structure, suffer continual alteration through the transposition of shadow and light; where the workings of latent heat allow no rest, but everything is in a state of perpetual vibration which causes lines to tremble and fulfils the law of eternal and universal movement.[8]

Here, painting, science, and poetry combine to produce *modern* art such as that which can see, beyond the seeming stability of things, their state of ceaseless movement – constant change, inner agitation, perpetual vibration, the trembling of the lines. Pure movement, without displacing the real, but creating the very thing that forms their visible trace: colour. Unlike the classical orthodoxy, for the modern person it is not from the subtlety of a drawing that truth may rise up, but rather, in the trembling of its outlines.

Trembling is what demonstrates that to live is to move. Movement is the lifeblood of every living thing, which is animated by, suffused with, and perhaps even destroyed by movement. The bridge between the nineteenth and twentieth centuries is also when epilepsy, hysteria, and trembling overran the human body, pure impersonal movement running through

7 Camille Flammarion, *Contemplations scientifiques*, 12. My emphasis.

8 Charles Baudelaire, 'On Colour', 48.

organisms or overflowing from them, subjecting individuals to an automatic agitation, neither within nor without, going beyond them and breaking them. Trembling, then, was the problem of medicine and psychiatry. Dr. Charcot wanted to control it and defeat it, but to do this he first had to show it: in his courses, 'he never described a symptom without, at the same time, making it seen visually.' Sick people were thus made to 'appear' as if before a court of law, as Henry Meige wrote in his book *Nouvelle Iconographie de la Salpêtrière* in 1898. Sometimes, however,

> The professor himself simulated those corporeal anomalies of the sick he could not show the class: an asymmetrical face in the case of facial paralysis, the different levels of hemiplegia, the festination and stiffness of Parkinson's patients, the grimaces associated with chorea, the gesticulations of persons with nervous tics and every variety of trembling.[9]

Trembling became the paradigmatic symptom, capable of an infinite variety of forms and intensities, leading to completely different diagnoses, each with a kind of common aura, that of demoniacs.[10]

Rae Beth Gordon has demonstrated the extent to which this trembling gesture permeated turn-of-the-century culture, through which a connection between the kinematograph and the café-concert was constructed and made visible. She remarks that

> There are many analogies between the convulsive, spasmodic and jerky movements of the hysterics and epileptics in Salpêtrière and those of the café-concert comics and singers of the same era. The new kinds of artist which came into being in the 1870s and 1880s were the Epileptic Comic and Singer, the Agitated Singer and the Comic Idiot.[11]

In this context, the cinema had a unique role: while it 'exalted hyperbolic movement, jolts, the automatisms of nervous illnesses, and instinct,' Gordon writes, this was also because 'the impression of the automatic and jerky gesture was, of course, heightened by the vibration of the image.'[12] The cinema, moreover, is not finished with early cinema's convulsive gestures

9 Henry Meige, 'Charcot artiste', *Nouvelle Iconographie de la Salpêtrière* 11 (1898), 493.

10 See Jean-Martin Charcot and Paul Richer, *Les Démoniaques dans l'art* (Paris: Adrien Delahaye and Emile Lecrosnier, 1887).

11 Rae Beth Gordon, 'Les Galipettes de l'Autre burlesque ou la mécanique corporelle du Double', *1895 revue d'histoire du cinéma* 61 (September 2010): 130.

12 Ibid., 131.

of nervous, pathological, or sexual irritation: in 1937, Georges Franju would point out its obsessive presence in the work of Fritz Lang.[13]

Étienne-Jules Marey plays a crucial role in this history of trembling, whose issues establish a continuity between graphic method and chronophotography and between medicine, the physical sciences, and the general visual culture. As François Dagognet remarked in 1987, Marey 'was able to record both the most minute and the most intimate forms of trembling.'[14] For Marey, the living was precisely that which was ceaselessly producing almost imperceptible tremors, but whose form – made visible through amplification and made analysable through a durable recording on a base – was meaningful and possibly revealed a symptom. The interrogation of the *form of the trembling* by the inscribing stylus lay at the heart of the graphic method.

This research and intellectual and perceptual surprises, far from being confined to physiological laboratories, would be widely disseminated by the photograph and gramophone, because here, too, the centrepiece of the *dispositif* was the form of the needle's trembling, almost imperceptible to the eye, but which carried the perfectly perceptible reproduced sound in all its complexity. This is an opportunity to emphasize here the equally visual nature of the gramophone *dispositif*: a rotating disc and the visual enigma of the groove and the vibrating needle, connected to the sound coming out of the horn.

With the passage to photography, the question of trembling was posed in a completely different manner for Marey, one which would also, with the spread of photography throughout society, be widely disseminated: that of motion blur. Blur was the great enemy of Marey the photographer, whose technical experiments sought a means to record movement in perfectly sharp images, because only such images could be quantified with accuracy. The relatively long period of time between the invention of photography and that of instantaneous photography had already made this specifically photographic blur penetrate the culture: the model must not move, but the photographer and the machine should not tremble either. The connection between blur and movement, between indecisive gestures and trembling, became so strong that when illustrators of the work of Charles Darwin in the 1870s had to depict a dog chasing its tail, for example, to express movement they adopted a slight blur, even if they were working with pencil, engraving, or

13 Georges Franju, 'Le Style de Fritz Lang', *Cinématographe*, March 1937. Reprinted in *Cahiers du cinéma* 101 (April 1959): 16-22.

14 François Dagognet, *Étienne-Jules Marey: La passion de la trace* (Paris: Hazan, 1987), 97.

oil paint. To this was added, when the work of Marey and the kinematograph had penetrated the culture, increased numbers of outlines and their possible indeterminacy; this was fundamental for the Futurists, for example in Giacomo Balla's famous 1912 painting *Dynamism of a Dog on a Leash*, to stay with the motif of the movement of a dog's tail. And it was precisely this blur, the effect of indecision around the outlines, the perceptible trembling in the image itself, which, through the interactions of the technical history of photography, the work of Marey and the kinematograph, would mark the history of perception and of visual culture, particularly in the avant-gardes of the 1910s and 20s.

Undoubtedly, it was the kinematograph that most crucially and fundamentally brought trembling into play. Cinema is the art of making images tremble, to make light itself tremble. Trembling, vibration, and jerkiness were the curse of the operator – both the camera operator and the operator of the projector – but they were also an essential feature of the machinery that established their place in the cultural circulation of modernity. This was the case with viewers' trembling bodies, as I described above, at Hale's Tours screenings and in the trembling gestures of early film comics. The kinematograph invented a radically new and hitherto unseen form of perception, based on trembling. It was precisely this aspect, moreover, which would disappear with the shift to the digital, because the digital does not tremble.

Trembling was, of course, not seen as a positive quality of the *dispositif*, but rather as a problem to be solved, a danger to remove, and an intrinsic limitation of the machine. In the very early years, a columnist for *Le Radical*, reporting on the 'new invention' on 30 December 1895, conceded a single defect at the end of his article: 'Their work will be a true marvel if they succeed in attenuating, if not in doing away with, which hardly seems possible, the vibration appearing in the foregrounds'.[15] This 'which hardly seems possible' gives an idea of the extent of the problem. In 1897, the Lumière Cinématographe notice warned users against this risk of 'vibrations': when the Cinématographe is set up, 'at the desired moment, the crank is turned at a rate of two turns per second, taking care to hold the device firmly with the left hand, pressing on its legs, to avoid shaking.'[16] The crank drive had many advantages, but one drawback: there was a good chance that the physical movement of the operator's arm would make the machine tremble.

15 Amonymous, 'L'illusion de la vie réelle . . .', *Le Radical*, 30 December 1895. Reprinted in Daniel Banda and José Moure, eds., *Le Cinéma: naissance d'un art. Premiers écrits (1895-1920)* (Paris: Flammarion, 2008), 40. Here, we again find the topology of the near and the distant.
16 Auguste and Louis Lumiere, *Notice sur le Cinématographe*, 19.

On this was superimposed, symmetrically, the lack of fixity in projection, a question that raised major technical questions in the process of inventing machines for showing moving images (the regularity of photograms on the film strip), but also around the *mechanical* nature of projection, with what this implies for the 'play' – as it is described by engineers – between the parts, and for the necessary tolerance for concrete imprecision in manufacture and assembly. Charles Le Fraper mentioned this aspect in his projection manual of 1912:

> Because the perforations determine the exact position of the images, it is preferable that films be perforated by a uniform machine. The reality unfortunately is quite other, and the fixity of the projection suffers as a result. Either the shape of the perforations does not match the teeth of the gearing cylinders, or the perforating machine is not precise and the images wobble, jump and produce a disagreeable impression.[17]

This play can be reduced, if the manufacturing process is precise enough, necessarily increasing the cost of production and thus the sale price of the machine or the price of admission. But it cannot disappear entirely. It is structural, tied up intrinsically with the very mechanics of the kinematograph. In 1906, Giustino Lorenzo expressed his confidence in 'technical progress' succeeding some day in 'doing away with trembling by increasing the *beat*,' meaning the number of images per second. This progress would give 'astonishing results' and make it possible in addition to 'make human movements more stable and resolute.'[18]

What Ferri described here as 'trembling' – in contrast, curiously, to the 'beat' – is flicker, which many years later would be of great interest to Stan Brakhage and to 'structural' filmmakers such as Peter Kubelka and Paul Sharits.

A study of 'technical progress' gives a good indication of the extent of the effect of this trembling on viewers' perception of the kinematograph in the very early years of the twentieth century. As was noted earlier, Charles Musser has remarked that, in his view, the year 1903 was a turning point in film history, in particular because of 'the introduction of the three-blade shutter on motion picture machines, which sharply reduced the flicker effect

17 [Charles Le Fraper], *Les Projections animées: Manuel pratique a l'usage des Directeurs de Cinéma, des Opérateurs, et de toutes les personnes qui s'intéressent à la Cinématographie* (Paris: Le Courrier cinématographique, n.d. [1912]), 7-8.

18 Giustino Lorenzo Ferri, 'Tra le quinte del cinematografo', *La Lettura: Rivista mensile del Corriere della Sera* 9 (October 1906). (Translated from the French – Trans.)

and made spectatorship much more pleasurable,'[19] thereby making it possible to lengthen films and screenings. In 1907, on an advertising poster by Jules Grün for the Théâtre du Cinématographe Pathé, showing an explorer trying to face down a lion, the screen promised: 'I do not tremble. I see everything'.

Viewers were also brought on board. In 1897, the 'Grille Gaumont' (Illus. 49) was patented, an 'aperture screen cancelling out the flicker effect in the perception of moving images.'[20] This strange *dispositif*, 'whose principle I do not fully understand, but whose effectiveness I have been able to observe,' Georges Mareschal wrote in *La Nature*,[21] looked like a perforated metal fan. As described by Georges Brunel, 'by interposing this grill between the eyes and the projected image and by giving it a slight back and forth movement, the vibrations are less noticeable and the images are remarkably sharp.'[22] Mareschal concluded that 'in the future this will be completely indispensable to any business projecting moving images.'[23] In this way, curiously enough, the trembling of the hand relieves the eye of flickering light. The minute and intimate tremors of human life appear to find singular and hard to explain resonances amongst themselves.[24] The problem must have been significant for someone to imagine that viewers, in order to rid themselves of the problem, would spend the whole screening moving such an accessory around in front of their eyes. In any event, this is not the first time, after Ducos du Hauron, that the viewer's body was pictured as being given singular repetitive and oscillating movements.

19 Charles Musser, 'The Stereopticon and Cinema: Media Form or Platform?', in François Albera and Maria Tortajada, eds., *Cine-Dispositives: Essays in Epistemology across Media* (Amsterdam: University of Amsterdam Press, 2015), 157.

20 Léon Gaumont, 'Écran à jours annulant les effets du scintillement dans la perception des vues animées', French patent no. 264,881, 11 March 1897.

21 Georges Mareschal, 'Les Erreurs du Cinématographe: Suppression du scintillement', *La Nature* 1249 (8 May 1897): 308.

22 Georges Brunel, *Les Projections mouvementées – Historique – Dispositif – Le Chronophotographe Demenÿ* (Paris: Comptoir général de photographie, 1897), 65. Quoted in Marie-Sophie Corcy, Jacques Malthête, Laurent Mannoni and Jean-Jacques Meusy, *Les Premieres Années de la société L. Gaumont et Cie: Correspondance commerciale de Léon Gaumont 1895-1899* (Paris: AFRHC/Bifi/Gaumont, 1998), 227.

23 Georges Mareschal, 'Les Erreurs du cinématographe', 368. This *dispositif* is also mentioned by Eugène Trutat in *La Photographie animée* (Paris: Gauthier-Villars, 1899), 175-176.

24 John B. Rathburn remarked in *Motion Picture Making and Exhibiting* in 1914, on the topic of the persistence of the visibility of the primary colours red and green, even at fast speeds: 'Even at this speed the independent colors may be distinguished by waving the hand between the eyes and the screen, an action that will result in a rapid red and green flicker on the edge of the hand' (p. 219). Here, too, we find a strange interaction between the eye, the hand, colour, and cinema's singular movement.

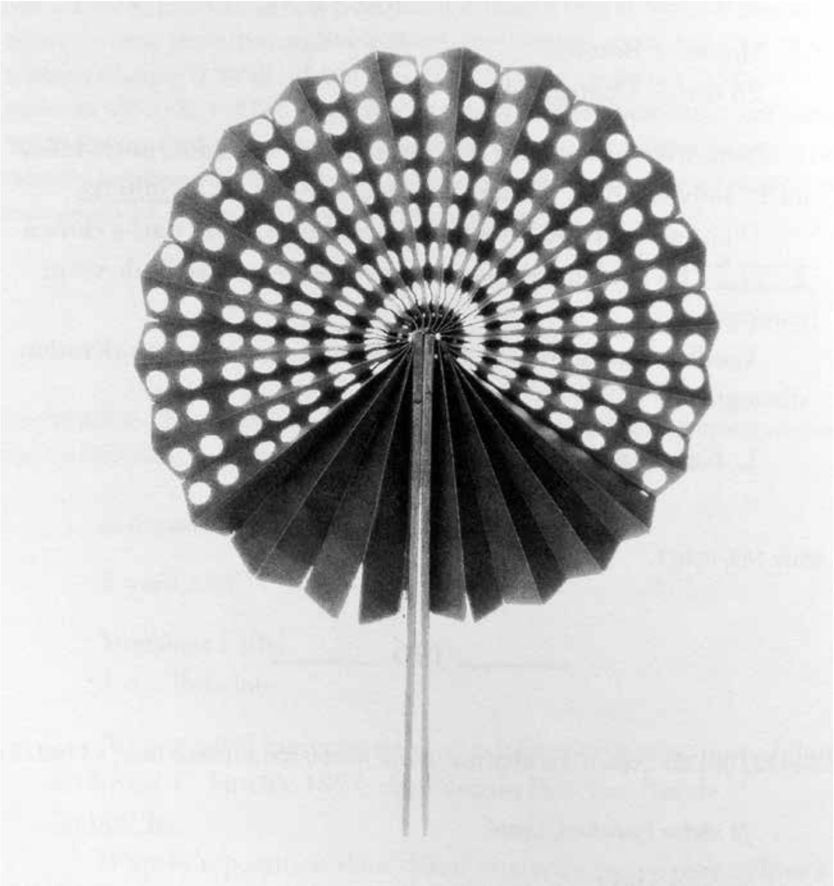


Illustration 49 – The 'Grille Gaumont'. From Correspondance commerciale de Léon Gaumont 1895-1899, 1998.

But these artifices did not definitively resolve the problem. Thierry Lefebvre showed in 1993 the extent to which, in the medical community in the 1910s in particular, solutions were sought to ocular pathologies seemingly caused by the cinema – described by Dr. Étienne Ginestous in 1909 as '*cinématophtalmies*'. It is likely that there was a degree of medical mythology in the anxiety around the emergence and role of this new medium in the culture; this would only confirm the importance of the perception of cinema as a flickering medium, as the mechanical and visual form of trembling or as the visual form of mechanical trembling. In the *Revue des deux mondes* in 1913, the drama critic René Doumic described the impression given upon first entering the darkened room where a film screening was being held:

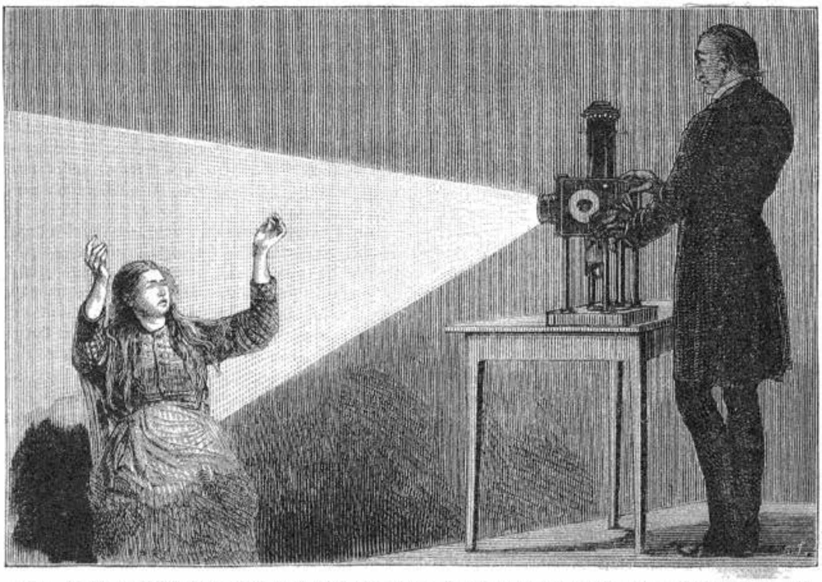


Fig. 1. — Catalepsie produite sous l'influence de la lumière électrique. — Cours de M. Charcot. (Dessiné d'après nature à la Salpêtrière.)

Illustration 50 – 'Catalepsie produite sous l'influence de la lumière électrique. Cours de M. Charcot'. La Nature, 1879.

> You take your seat, your eyes open wide, and what they see first of all, on the luminous screen whose lit surface alone pierces the shadows, is a constant trembling. It vibrates, it wavers, it shakes, it doesn't stop trembling. You make a greater effort to adapt. You make out forms, singular forms, forms of moving objects and beings.[25]

The perception of trembling, in all its forms and variations – vibration, wavering, shaking – was foremost and fundamental. It was only through effort that the eye could overcome this pulsatile state and *see something*. The connections between trembling light and trembling gestures was clear at the time. In his classes, Charcot, for example, provoked catalepsies by projecting electric light onto the patient (Illus. 50).[26]

Beyond the thematic connections with contemporary machinery and urban life, beyond a common set of gestures that ran through the cinema in singular fashion, it was profoundly through trembling that the new medium was a part of and forged modernity. Cinema was the art of the new molecular

25 René Doumic, 'L'Âge du cinéma', *Revue des deux mondes* 16, no. 6 (15 August 1913): 920.

26 Dr. A. Cartaz, 'Du somnambulisme et du magnétisme: À propos du cours du Dr Charcot à la Salpêtrière', *La Nature* 294 (18 January 1879): 104.

and undulating world whose material itself, which appeared so solid, turned out to be made up only of vibrations, movements, and trembling. The cinema was the art of the body of its day and was also shaped by this vast impersonal movement, to which was added the quivering proper to living things.

Within this culture of trembling, colour had a special role for a number of reasons. Firstly, colour is the visible and evident manifestation of the vibrating nature of light, as we saw in Baudelaire. Next, and for that reason, colour and movement have had a very deep cultural connection, seen in the number of toys and entertainments of pure colour in movement, from the coloured tops of Newton and Maxwell and chromatrope magic lantern slides to colour organs, colour symphonies, etc. These would culminate in the 1910s in the origins of abstraction, particularly in the work of Robert Delaunay, which Pierre Francastel described as founded on 'the systematic use of the animation capabilities of pure colour,'[27] and in the discovery of cinema by artists interested most of all in the connections between colour and movement – around Futurism with Bruno Corra and Arnaldo Ginna, and then around the Bauhaus with Hans Richter and Viking Eggeling.

This research played out an old quarrel, that of drawing and colour. Colour has always threatened the outlines of a drawing by spilling over it, threatening the sharpness of the line. It has always been what Baudelaire described as 'that which makes lines tremble.' To put it a little differently, it was always the feminine, in contrast with the masculine nature of drawing: uncontrollable in practical terms, against the controlling; the trembling of the hysteric, who was a woman, against the sharp, assured, viral – and signifying – gesture. The effect of Taylorism on workers' gestures, carried out from the 1910s to the 1930s by Franck and Lilian Gilbreth on the basis of a post-Marey visual method, sought, precisely, the elimination of trembling in procedures, the control of the hand and smooth gestures.[28] Here, trembling is what resists and what industrial capitalism must in the end eliminate.

Kinemacolor was exactly contemporaneous with these questions. And yet, the procedure was absolutely singular in that, through so-called temporal

27 Pierre Francastel, 'La Couleur dans la peinture contemporaine', in Ignace Meyerson, ed., *Problèmes de la couleur: exposés et discussions du Colloque du Centre de recherches de psychologie comparative, Paris, 18-20 May 1954* (Paris: SEVPEN). Reprinted in Francastel, *L'Image, la vision et l'imagination* (Paris: Denoël/Gonthier, 1983), 239.

28 See for example Frank B. Gilbreth, *Motion Study: A Method for Increasing the Efficiency of the Workman* (New York: D. Van Nostrand, 1911); and Scott Curtis, 'Images of Efficiency: The Films of Frank B. Gilbreth', in Vinzenz Hediger and Patrick Vonderau, eds., *Films That Work: Industrial Film and the Productivity of Media* (Amsterdam: Amsterdam University Press, 2009), 85-99.

parallax, which was described as one of its major structural drawbacks, green and red fringes were constantly appearing on screen as soon as the image began to move. Kinemacolor produced a singular mode of perception: a trembling of lines, an indecisiveness of contours, which is not a form of blurring but a doubling of the line running from image to image, making reappear visually for the viewer, in the form of 'image-movement', the nature of the film as a series of photograms.

One of the things that the Cinématographe and Kinemacolor enable us to recover is the trembling that is the essence of cinema as a medium and *dispositif*: trembling as pure movement, without displacement, infinitely unstable without movement – life itself. This trembling is inscribed in the machines, which archive its secret. It can be analysed only in part through the study of the patents and devices that have been preserved: it exists only in experiencing the machine in operation. To understand its extent, technology must incorporate methods for analysing the discourses of the epistemology of *dispositifs* and of cultural history. Trembling could, then, let us see something like an archaeology of modern perception, a trembling constantly rejected, refused, feared, suppressed, but always secretly coiled within modern culture, which today may be over.

Towards a Technology and Archaeology of the Digital

It is primarily as a consequence of these points that the shift to the digital coding of moving images has introduced the most apparent perceptual and epistemological transformations. Nothing trembles in 'digital cinema'. Nothing trembles on the screen, because nothing trembles in the machine. 'Traditional' silver gelatin cinema (if we were to call it that) – of which the Cinématographe and Kinemacolor were the two exemplary embodiments, even though each was eccentric – was conceived in the cultural, historical, and epistemological framework of mechanization.[29] There is in all of these devices, very concretely, 'movement in the machine,' as Bergson said. A mechanical movement that brought with it vibration, shaking, and jolts. These were problematic but inevitable; disagreeable but the traces of the

29 On this point, I take the liberty of directing the reader to my article 'Toward an Archaeology of the Cinema/Technology Relation: From Mechanization to "Digital Cinema"', in Annie van den Oever, ed., *Téchnē/Technology: Researching Cinema and Media Technologies, Their Development, Use and Impact* (Amsterdam: Amsterdam University Press, 2013).

intimate movement that makes every thing quiver. The movement of digital cinema occurs without any mechanical element.

Behind the lens, a fixed light-sensitive sensor has replaced the moving film. It is composed of an immobile group of photosites capturing, at a rate of 24 times per second,[30] a quantity of light that they transcribe in the form of an electrical signal and transmit to an electronic system. This system codes the signal in digital form in a certain quantity of bits, whose number determines the precision of the image. This data is then stored on a magnetic band – which advances according to the same principle as a strip of film, albeit continuously – on a memory card or hard disk, the latter having the capacity to be set in motion with a mechanical movement (a magnetic disk turning during inscription was the most widely used system) or not (SSD or Solid State Drive-type disks, which are more expensive but also quicker and less fragile).

As photosites are sensitive only to the quantity of light, the colour information must be produced by superimposing a coloured matrix over the sensor – most frequently this is a Bayer matrix, which astutely divides up the green, blue, and red filters on each of the photosites. The colour of each 'pixel' (an abbreviation of the term 'picture element') in the final image is then reconstructed by calculation (the 'unmatrixing' operation) based on the information collected by the photosite corresponding to the sensor, but also that of neighbouring photosites, correctly balanced. Then, on a screening monitor (a television set, a computer, etc.) or in projection, the colour is recreated through additive synthesis of the three primary colours for each pixel.

The large numbers involved here – a '2K' image has more than two million pixels, each tied to three kinds of colour information (red, green, and blue) coded onto eight bits – requires that another phase be introduced to the process: that of compression, making it possible to produce a manageable flow of data. This compression counts on the redundancies perceived in each image (intra-image compression) or from one image to the next (inter-image compression), and on the calculation possibilities through interpolation for data which is near (the matrixing of colour is already a compression operation).

For today's forms of circulating 'digital video' files (DVD, online streaming, etc.), inter-image compression is mostly used, to greatly varying degrees. It is efficient, in that it can noticeably reduce the size of the files, based on the fact that in normal film production a very large proportion of the photograms

30 For 'Digital Cinema' procedures, as defined under the prevailing standards at the time of writing for movie-theatre projection (DCI in North America, CST in France).

resemble their immediate neighbours a great deal – this is the definition of a 'shot' in cinema. Nevertheless, it presents numerous problems. Firstly, it is incompatible with editing, or, at least, with the kind of editing that seeks to cut on a particular image. For, in these files, elementary images are reconstituted according to the data recuperated in the preceding images. The 'photogram', as a complete and coherent image, has thus ceased to exist and is not concretely accessible for cutting. Hence 'professional' digital recording formats limit themselves to intra-image compression. Next, inter-image compression produces jerks in the camera movement that are perceptible to varying degrees depending on the mode and degree of compression, and on the speed of the camera movement, the subject being filmed, etc. This 'choppiness' of pans and tracking shots is a new kind of movement typically associated with the digital, just as 'jpeg'-type compression for fixed images has become a completely new form of image whose aesthetic potential a photographer such as Thomas Ruff has been able to discover. In any event, these possible jumps have led to standards for digital projection (DCI, CST, etc.) that forbid inter-image compression.

These fundamental principles of the digital – which would have to be described in detail in order to gauge the theoretical gaps brought about by their significant concrete variations – construct an epistemological framework of the digital moving image radically different from that of the moving image on a photo-chemical base.

The digital moving image is elaborated apart from mechanics and apart from chemistry. It is part of the reign of the electric and the electronic – a reign contemporaneous historically with the former, but more volatile and tied to another imaginary. The digital image is not dematerialized; it is still inscribed somewhere on a physical base, that of a magnetic band or hard disk, but when this form is stored or coded it is no longer visible.

The digital image is also fundamentally conceived as a discontinuous aggregate or collection of well-ordered but independent pixels. This image is no longer the absolutely coherent ensemble of the silver gelatin image; it is divisible, disconnected. This is what gives it its malleability and what makes it possible for digital colour timing – through which colours are adjusted in the laboratory – to treat zones of images in a way that was not as simple with silver gelatin film. This fundamental divisibility of the digital image has created an epistemological framework that, as I mentioned above, has come to encompass the silver gelatin image: the digital pixel and the grain of the silver gelatin emulsion have been described as equivalent, if only to debate the question. But the silver gelatin image was never conceived as an aggregate of grains *before the digital* – except in the precise technical discipline known as sensitometry, the study of the sensitivity of emulsions. Grain shows through only as an aesthetic material of the image, as a granular quality that can be worked for its own sake without the grains becoming autonomous, without any loss of the image's coherence or plastic or conceptual unity. The grain, in the singular, is a sign that today the silver gelatin image is conceived in an epistemological framework centred on digital practices, and not the other way around.

Yet, compression brings the coherence of the image back into play. Through compression, each pixel is no longer completely independent: it is the result of a calculation operation involving not a sole photosite, but rather a group of photosites in close proximity: local blocks arranged within each other. There is thus a topology of the digital image operating by vicinities perceptible to greater or lesser degrees by the viewer, agglomerating pixels into an ensemble which can no longer be so simply divided. Even supposedly non-compressed images ('raw' images) are elaborated out of matrixing/unmatrixing operations to create a de facto connection between pixels. But this does not prevent the digital imaginary from being constructed as an imaginary of discontinuity, of infinite divisibility – and of the imperceptibility of the distinction between continuous and discontinuous.

Just when cinema was emerging, the mathematician Georg Cantor in particular had established the idea of an essential distinction between the continuous and the discontinuous. The former was seen as being completely other in nature, inaccessible to common intuition.[31] The place of the digital in contemporary culture is tending to erode this distinction, as all continuous phenomena (movement, sound, etc.) can be discontinuously quantified digitally, as long as this process manages to carry out a *fine enough* dividing up of the phenomenon. This 'fine enough' has to do with the idea of a perceptual threshold beyond which the human perception apparatus is not capable of seeing, hearing, or feeling discontinuity. It is likely that this idea was born with the cinema, or rather with thinking about nineteenth-century optical toys and the notion of the 'persistence of vision' associated with them.

The digital is distinct from the technical system of kinematography on a photo-chemical base on another level as well. As we have seen, cinema in 'natural colours' became technically and economically viable over the long term only with the adoption of subtractive colour synthesis procedures. The

31 On the issues raised by this distinction, see the work of Jean Cavaillès, and in particular his article 'Transfini et continu', written around 1940-1941, in *Oeuvres complètes de philosophie des sciences* (Paris: Hermann, 1994), 451-472.

first procedures marketed commercially – Urban and Smith's Kinemacolor, Gaumont's Chronochrome – were additive synthesis procedures. They were complex to use and made it necessary to modify or change the projection equipment. The 'winning' procedures – Technicolor and later Eastmancolor – were subtractive synthesis procedures: the colours appeared in the film itself, which could be projected using standard equipment. The digital is an additive synthesis procedure. It also necessitates the changing of all the projection equipment in every movie theatre, and the colours it renders depend on the viewing system, with each device having to be adjusted as rigorously as possible, but it is impossible to do so in a way that is exactly identical each time. And yet, the supposed incompatibility of these additive procedures with cinema's technical system, which was the argument used to account for the ultimate failure of Kinemacolor and Chronochrome in the mid-1910s, does not appear to pose a problem for the digital. It all seems as if the status of the digital in the culture makes plain the need for this transition, apart from its financial consequences.

All this can only be a sketch of a technology of digital cinema. This cinema appears to be a new technical system whose coherence is constructed on economic and epistemological bases that are relatively different from 'pre-digital' mechanical and photo-chemical cinema. Beyond evoking these principles, it will be necessary to carry out a precise study connecting all of its dimensions, taking into account the new uses it has made possible through all its variants, from the iPhone to very high-end professional cameras. The task will be to discover the new aesthetic possibilities opened up by these new tools: their different perception of depth of field; their different rendering of low levels of lighting; their different kinds of blur; the different ways they tier depth-of-field shots; their different colour palette; the formal issues raised by the visual 'noise' connected to the amplification of the signal, etc. These transformations must be connected to new practices, each one different according to the material being used, but also according to the cultural, economic, historical, and political and other contexts – including questions of gender, or issues of global politics and ecology. The coherent overall technical system that makes up 'digital cinema' has redistributed and rearranged all of these factors, and an analysis of them must both make distinctions between them and understand their cohesion.

Only close attention to a technical history of technics can make it possible to elaborate its social, economic, and aesthetic implications. This alone will make it possible to gauge the extent of technical transformations, whether these be the evolution of the form of camera viewfinders, the introduction of video monitors or splicing with tape, the positioning of the hand crank or the choice of focal length, the issues around the shape of a machine, the implications of colour and sound procedures, or the massive abandonment of the silver gelatin base for the digital when shooting or projecting images. The issues raised by these transformations go far beyond the level of use, with which they interact in a complex fashion through a range of reciprocal determinations, adaptations and reconfigurations, touching on both dominant practices and the 'misuses'[32] of amateurs, artists, and experimental practitioners. But these issues too, as I hope to have shown, are also found in the implications of the form and structure of machines – implications that could be developed by an epistemology of machines.

The mechanisms themselves, the internal organization of the 'camera obscura' that makes up the device, play a fundamental role in the historical function of the machine and what it can tell us about the historical state of culture and ideas at a certain point in time. The way in which a machine brings an issue into play and presents itself as the solution to a singular problem articulates an 'implicit conceptual structure' whose hypotheses constitute (construct and archive) a unique system at once epistemological and perceptual. The history of machines is not tied to a history of ideas, but rather to a history of problems, and the process of positing each individual problem orients each machine, both in its singularity as individual technique, and in its place within a technical species which is also a lineage of issues. The technology of these machines must thus be a history, an archaeology, and an epistemology. This is how the complexity of media machines, of viewing and listening *dispostifs*, can be grasped, right up to their aesthetic and political dimensions. As Gilbert Simondon remarked,

> Not only the consequences but also the conditions of the genesis of an invention involve collective content and historical aspects, with the particular manner in which knowledge and power are transmitted in the form of constituted objects or production procedures, and with the requirement that there be reception conditions which are not only economic but also cultural.[33]

32 Gabriele Jutz, at the conference 'Techniques, machines, dispositifs: Perspectives pour une nouvelle histoire technologique du cinéma' (Lausanne, November 2012), presented a paper entitled 'The Avant-Garde and Its "Mis-Use" of Existing Technology', which elaborated on an idea proposed by Peter Wollen in his article 'Cinema and Technology: A Historical Overview' in Teresa de Lauretis and Stephen Heath, eds., *The Cinematic Apparatus* (London: Macmillan, 1980).
33 Gilbert Simondon, *L'Invention dans les techniques*, 293.

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