AMIA Tech Review

From the Association of Moving Image Archivists

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Welcome to the third issue of the *AMIA Tech Review*. Unlike Gaul, this issue is split into four parts: Digital, Analog, new items already here and those on the horizon, and finally, points of historical interest. MORE

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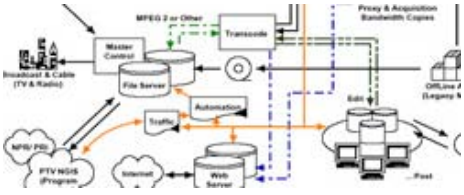

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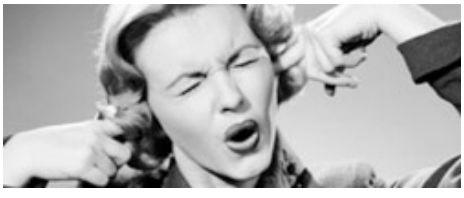

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CONTRIBUTING AUTHORS

Bob Heiber
Nicola Mazzanti
Chris Reynolds
Nan Rubin
Ken Weissman

UPCOMING EVENTS Click for Details

May 11-14	ARSC Conference
June 22-26	ACVL Conference
August 19-20	The Reel Thing XXVII: LA
September 30	DAS 2011
October 24-27	SMPTE Tech Conference
October 27	World Day for AV Heritage
November 16-19	AMIA 2011: Austin, TX
March 1-4, 2012	AES Conference

Save the Dates!

August 19-20: The Reel Thing
September 30: DAS 2011
November 16-19: AMIA 2011

AMIA Tech Review
From the Association of Moving Image Archivists

April, 2011 | Issue 3

Editor's Notes

By Ralph Sargent

Welcome to the third issue of the AMIA Tech Review. Unlike Gaul, this issue is split into four parts: Digital, Analog, new items already here and those on the horizon, and finally, points of historical interest.

Nicola Mazzanti follows up on the topic of Digital Cinema (first introduced by Arne Nowak in Issue 2) with a stirring ramble on what happens when an entire country is converted to digital cinema and all the virtues and vices of film-based cinema are declared dead and buried at the stroke of the pen! Though technical terms are bandied about with jocund abandon, don't let this stop you from grasping the finer points, both physical and psychological, when Nicola drills into the psyche of an archivist confronted by a new world and worried that the finer points of the last century's love affair with film will be lost in the rush toward totally electronic images.

On the contrary, Ken Weissman delivers the point of view of the United States' largest archive, the Library of Congress. Ken's dilemma is one of sheer quantity: the thousands upon thousands of reels of film and other media in the Library's collection. What to do? Read Ken's response.

Our thanks and praise to Nan Rubin for being the first person to voluntarily submit -meaning not coerced by the editor - an article to the Tech Review. Nan's article is about the Corporation for Public Broadcasting's PBCore Metadata project, how it came about, its various revisions and its implementation. Everyone in AMIA knows how librarians and archivists love metadata, and this brief article should wet their whistles to dive in and create a similar and truly functional, fully inclusive database for film-based archives. Thanks Nan!

Bob Heiber of Chace Productions by Deluxe has contributed an article on the various generations of soundtracks for *The Bridge on the River Kwai*. Once and for all the squabbles in film fans' blogs concerning what the truth is regarding *Kwai*'s sound can be laid to rest. Bob's the man who knows….

Also from Chace comes an article addressing "Loudness" on television, what the US Congress may be doing about it, and how the sound engineers will have to respond if Congress and the networks say, "Do it!" No more eardrums banging from commercial devotees of *yell and sell.*

Finally we end with a commentary on and a reprint of a chapter from the book, “Motion Pictures, How They are Made and Worked” published in 1914. This should let all of our early silent film fans know where those odd processing and printing fluffs came from and why. This truly is a look backward but an interesting and amusing one at that.

I would also like to recommend to our readers that they acquire and read a copy of the January/February 2011 issue of SMPTE’s “Motion Imaging Journal.” It is a single-topic issue on “Archiving and Retrieval” of digital motion pictures. I’m pleased to note that our publication of Sean McKee’s and Victor Panov’s article on “The Visionary Archive Process” in Issue 2 of the AMIA Tech Review was picked up by SMPTE in an amplified version. “Visionary…” and four other articles help the reader to know where our field is headed and consider how to be prepared for changes that surely will come.

And now, the boilerplate:

Those of you who feel you have appropriate material to contribute, please feel free to advise us via a thematic proposal or précis of your article. If accepted for publication, your articles should be received at the AMIA office no later than six weeks prior to next publication date. (Please email Laura Rooney at the AMIA Office for anticipated publication dates.) All articles or suggestions submitted are subject to review, condensation or augmentation and editing.

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We encourage readers of the AMIA Tech Review to become members of ancillary trade associations such as the National Association of Broadcasters, the Audio Engineering Society, the Society of Television Engineers, the Society of Motion Picture and Television Engineers, etc. Cross-pollination of technical information is important and we strongly support it!

Finally, please let us know what you think. It never hurts to speak your mind in a civil and constructive manner. If there is some aspect of this publication you feel could be improved, please let us know. If there is something you liked, let us know. You get the idea….

Best wishes and see you in Austin in November!

Ralph Sargent, editor

AMIA Tech Review
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April, 2011 | Issue 3

Goodbye, Dawson City, Goodbye

Digital Cinema Technologies from the Archive's Perspective: Part 2

By Nicola Mazzanti

So, it's here. It has arrived, and it is here to stay. Digitization of cinema, "from capture to projection," is really here.

Film archives have been nervously waiting and actively getting ready for it for quite some time now, starting in 2002 when the European project FIRST[i] provided the opportunity for 'brainstorming' about the future and the impact of digital on cinema archives. At the time few people in the field thought that Digital Cinema would come true – at least not any time soon. This was quite understandable as 2002 was the year when DCI-Digital Cinema Initiative[ii] was created, and only a few years had passed since the very first feature film had been produced with the process that we now call Digital Intermediate – although at the time it did not have a name.

Of course after that, much work was done by archives and other bodies, to wit: The Academy of Motion Picture Arts and Sciences' classic, groundbreaking report "The Digital Dilemma"; the work at the Library of Congress within NDIIPP[iii]; on a more technical accent, the recent EDCINE[iv] project; the work on ISO-standardized JPEG 2000 profiles for long-term preservation[v]; and the introduction of silent frame rates in the D-Cinema standards.[vi] The list of activities showing how hard archives worked to get ready for a complete shift to digital technologies has become quite long and will surely be added to in the future. Whether the early preparation was sufficient is a story which can be left to historians; right now it's time to face the fact that the horse is out of the barn: **cinema has become digital.**

Actually, I use the phrase "the horse is out of the barn" in the strictest sense, as in "*Belgium, 2011.*" This is one of the first countries to have completely switched to D-Cinema, with hardly any commercial theatres operating 35mm projectors anymore.

In a way I can say that I am a 'privileged' spectator and a highly interested one. And as such I can say that no matter how prepared you were, or how much you discussed, analyzed and dissected the issue, when it happened, it was still a surprise and a shock. In a way it was like a tornado or hurricane had hit the ground. You saw it coming, expected it, but when it finally really hit, you were still somehow caught by surprise as secretly, at some level, you still hoped it would simply go away – and frankly, that's exactly what some archivists had hoped for a while.

Well, this digital tornado hit with full force.

In fact the very first thing that strikes you is how quick the page turns, how fast a whole market flips. In the case of Belgium the limited size of the market helped. Still, when the decision to 'go digital' was announced, all screens and all theaters became digital practically at once and suddenly, hardly any 35mm projectors were left behind.

Lesson One: Don't bank on a nice, easy transitional period where the two technologies (film and digital) happily coexist or at least where 35mm is kept as a safe, familiar backup. This is just wishful thinking! 35mm is not meant to stay. 35mm machines are being dismantled, sold, thrown away – with the exception of some multiplexes where one projector is left in one of the theatres, "just in case" for a year or two.

None of this is really surprising, as keeping two systems in operation is both not economical and not really that useful. For many years now we've been warning that other similar industrial restructuring processes show a pretty consistent pattern: the rate at which an aging technology is replaced is slow at first, then it accelerates until reaching a sort of 'breaking point' when keeping the old technology alive becomes both technically too complex and economically unsustainable. At that point the process suddenly shifts to "warp speed" and it is very soon over.

So went the theory… and reality wasn't far behind.

Although I was one amongst others who had been preaching and warning about the consequences the shift to digital would entail, when it actually happened, I was dumbstruck by the sudden disappearance of all things analog. Literally overnight projection equipment's maintenance and service became costly and either hard or impossible to obtain; film labs reduced their services while trying to 'restructure'; suddenly your viewing prints could no longer be shown at schools and universities and others couldn't find a theatre with 35mm projectors anymore.

Lesson Two: As soon as distribution turns digital, one can really read the writing on the wall: film origination and the scanning of it won't last long either. Digital image capture will inexorably expand.

I admit that what follows is not really a neatly organized strategy to deal with the change, as this will require time and adaptation to a technical and industrial landscape that is in constant, deep and fast evolution. Besides, we have to realize that the consequences impact all aspects of an archive – from acquisition to programming, cataloguing, distribution and access – not just preservation and collection management. This is a landscape that is much broader than what I can discuss here. So, please consider all of this as a collection of loose thoughts aiming at nothing more than starting a discussion.

In the previous issue of the AMIA Tech Review, Arne Nowak did an excellent job of breaking down the whole D-Cinema process from an archival perspective. I am sure that his article greatly contributed in helping people understand a few basic and critical points beyond the intricacies of the process.

The process is indeed complex, with the complexity largely due to the fact that it is new and experience with it is limited. I also think that Arne's article showed that the process is ultimately manageable and that it is absolutely reasonable to assume that this technology will become easily available even in the short term. What I am saying is this: a fully compliant DCP can be produced in-house or even at home with reasonably priced software and hardware and even with free, open source tools.

In other words, if we look at the process of producing digital viewing elements for theatres it's clear that archives should be able to produce DCPs completely in-house. Objectively speaking (and setting aside our obvious lack of experience,) this is far less complicated than producing a 16mm or 35mm release print. Consider the chemistry involved in processing, sensitometry, or the art of properly setting up a printer or the many other technical considerations required for best results – we all know this is not trivial.

Viewed from a pure cost/benefit standpoint, there is even less competition between film and DCP production. The last DCP we produced was done on a 3 year old Mac and while it took 6 times the running time to complete, it worked out well on the very first try. (If you want to spend some money, there are technologies out there that can do the job in real time). Compare that with a full-fledged wet or dry lab. Please understand that I am not arguing that one display medium is "better" than the other, I am simply arguing against the concept that making a DCP is a complex, costly and ultimately impossible endeavor. The reality is that producing a DCP is something that already is much more easily within the reach of an archivist and an archive than printing and processing a film print. And it is so much cheaper – even now when it is still a 'new process' – whether it is done in-house or if it is outsourced to the many companies offering the service. Considering all of this, I see no reason why archives shouldn't get equipped to carry out the process in-house.

However, there are caveats to this type of thinking. While it is somehow a relief to think that producing new digital projection elements is necessary so that our films can be watched in this new environment, is this not a self-defeating concept for an archive? Following this logic pretty much sets us up for a future in which we will not be able to screen those film prints we cherish so much anywhere else *but* in our own theatres and even this will become more costly and more complex until it will be practically impossible. Even so, we can argue that this is what we *should* do, that we *should* turn our archives into real museums, making them perhaps the only places where a film-originated work can be seen as it was intended to be seen: with an audience, on a screen, illuminated by a film projector. But in the digital age the demise of this concept may not be a matter of if, but when.

On the other hand, we all know that this is not the only issue. There are many others.

Lesson Three: Don't fall in love with today's methods of digital storage. Knock film all you want, but one thing it does extremely well is survive. Once a piece of film stock gets out of the lab and into our archives the chances for a long life are pretty much guaranteed provided it is kept in a cool, dry place and the archive exercises reasonable care.

Unfortunately, digital media does not have such a secure and validated reputation. The instability and volatility of a digital file and the complexity of handling a *large* collection of *large* digital files is well documented. Please note that the adjective 'large' is the key element here. Holding a 300 GB file in your collections is not that difficult, costly or complex. But multiply it by 1,000 (plus throw in some Digital Cinema Distribution Masters, or DCDMS, each worth a few Terabytes) and you actually have a problem. The problem becomes even bigger when you project that in the future all of this – those 1,000 files or more – will have to migrate from one medium or system to another. Not to mention that format issues might arise with time and might require some form of format migration.

Lesson Four: 'Format stability' is a very serious issue.

In theory, the whole D-Cinema process is almost fully described and defined by SMPTE standards. Standards for professional applications are usually more stable than others and there is a strong chance that D-Cinema standards will last a while. This is because the consequences of a change will be too costly after the initial transition is complete. Nobody wants to buy new projectors and servers too often. Still, if we look at this from an archival perspective, it is both possible and probable that within the next 10-15 years something will change.

With computing power constantly improving and storage constantly decreasing in cost and complexity, it is not hard to imagine that sooner rather than later we will see D-Cinema going beyond its current specs. Examples include: higher resolutions like 8K, higher bit depths, the possibility of more extensive use of higher frame rates (frame rates other than 24 and 48, from silent frame rates up to 60fps are already in the standards, and they might be used some day), development of new display technologies (laser projectors or very large "active" screens rather than projected images are two solutions currently being proposed), and improvements in sound. (Wavefield synthesis is what we need!)

Similar developments and others that I have undoubtedly overlooked or I don't see coming are likely to impact the existing standards in the future. This won't happen tomorrow, but in 'archival time' we can surely expect this to happen and we should start planning for these changes now. This implies having format migration in mind. In turn this means making sure that we have our technical metadata straight.

Lesson Five: Taking accurate metadata is essential and unavoidable!

I might be wrong, but I suspect that many film archives today may not be fully equipped to properly describe, from a technical standpoint, digital masters or projection copies that are already coming into their collections. In this sense and context, it is my humble opinion that becoming 'fully equipped' entails acquiring three necessary capabilities.

1. Adopting some sort of metadata schema allowing the recording of the technical characteristics of the digital object (at ingest and all along its life cycle, including at migrations).

2. Acquiring the proper hardware and software tools necessary to inspect, analyze, and check the digital object, both at ingest and all along its life-cycle.

3. Developing the necessary know-how within the staff to apply the above to the many digital formats that are being, will be, or might be ingested.

At the moment, I think most of my concerns lie somewhere in these three areas, at least when we look at the issue from the point of view of digital element ingestion, long term preservation, and collection management.

Work has been done on the metadata issue, but I am under the impression that there is still work to do in the real-life application of the schemata that are available, particularly in the interaction with issues 2 and 3. The situation is even more critical when it comes to methods or technical solutions to track down and record 'historical technical metadata' that describe the processes and transformations that are applied to a given digital object during format migrations or conversions aimed at creating an access element. Such metadata are critical to be able to identify the correct version of a given title, to make sure that the right version is produced, or to reconstruct retroactively what happened to a given file. Clearly, this is something that cannot be done manually as it is both excessively time consuming for a large collection and impossible for certain types of information that can only be gathered by software.

Hardware and software solutions for ingestion are not an easy issue either. First, a major concern is the cost. Today most public and private commercial archives are faced with what one can politely describe as a not brilliant economic environment. Second, selecting software and hardware today is not easy, nor is it easy to implement the 'right' hardware and software solutions into the everyday operations of an archive.

Lesson Six: Basic ingestion requirements may entail more fact-finding than previously found in traditional film archives. (The following sketches a pattern of basic actions which will have to be performed upon acquisition of materials.)

1) Similar to analog days, an archive needs to perform a proper ingest process that requires inspecting the incoming elements, assessing their conditions, and the recording of the necessary metadata. It does not matter here if they are deposited, acquired from a service provider (digitization/restoration lab) or internally produced (Do you *really* trust the guys in the other department?). Elements to be ingested must be checked against what they are supposed to be, labeled to be, and listed to be. Obviously the list of possible incoming formats depends very much on the workflows used internally and, concerning deposited elements, the industrial environment the archive operates in.

2) If we look at DSMs (Digital Source Masters i.e. the format that originated a DCDM and then a DCP), we are confronted with a wide range of HD video formats, both tape- and file-based, plus differently flavored DPX, TIFF, JPEG 2000 and sound files. Tape-based formats are 'easy' in the sense that one *just* needs the right machine, but the costs are very significant as one needs more or less one machine per format. File-based elements can be handled with a wide range of software/hardware combinations and the good thing is that the entry level can be relatively low: there are many medium priced (or even free) software solutions to open JPEG 2000 or DPX images, and pretty reasonably priced hardware can be

sufficient at least at some basic level. Not to mention that it is very possible that the tendency, inaugurated by Blackmagic, to lower the price of digital postproduction tools able to handle 2k and 4k can be followed by others, taking it down to almost a prosumer level.

3) In its unencrypted form, a DCP is even easier to handle. Just as an example, we can check DCPs on a rather 'normal' dual Quad-Core MacPro using Fraunhofer's software. 2k DCPs would run at 24fps (or slightly more), for real-time 4k (or 3D) one would need something better than a 3 year old machine. Similar performances can be also obtained on PCs, of course, and other solutions are available with other vendors.

Obviously, the real issue of encrypted DCPs is not so much that one needs the proper software to open them, or that the de-crypting process uses up some computing power – the real problem is the availability of the keys.

Actually, this is also fairly simple: if you do not have a key there is pretty much nothing you can do except copy the file as it is, and pray very intensely that (1) it contains what it says and it is not corrupted, and (2) it does not get corrupted later. Ultimately, real long term preservation of encrypted DCPs without access to the keys is simply impossible.

In my opinion, no archive should ever accept encrypted DCPs without keys as a deposit format whenever long-term or even short term-preservation is in the picture. It is probably good to remember at this point that, as Arne Nowak explained and contrary to what many people think, encryption of DCPs is not mandatory. It is common practice, but it is not mandatory.

The Technical Commission of the International Federation of Film Archives (FIAF) recently issued a recommendation, "On the deposit and acquisition of D-cinema elements for long term preservation and access,"[vii] which discusses the different issues and concludes:

1. *Only a DCDM or an unencrypted DCP are acceptable formats for the long-term preservation of a cinema work. Archives must be aware that a DCDM will be considerably larger than a DCP.*
2. *A DSM can also be accepted, but not in place of a DCDM or DCP.* [viii]

As the delivery of an unencrypted DCP might be considered risky, another alternative (that is discussed both in Arne's article and the FIAF recommendation) is to provide the archive with an encrypted DCP that can be decrypted with a so-called "Distribution KDM" (the term "Studio KDM" is also sometimes used).

As Arne explains, "Distribution KDMs" are

> *KDMs that can be used with special software to decrypt the DCPs in a secure and controlled environment on the archive's premises. This would secure the transmission but also give archives the possibility to take care of the long-term preservation of today's digital films for the future.*[ix]

In practice this means that the archive receives an encrypted DCP as well as a Distribution KDM, a key that works only on a specific trusted software/hardware environment. The key is then used in that secure environment to decrypt the DCP. At this point the archive can decide to store securely the unencrypted DCP in its own storage system or it can produce a new DCP encrypted with a new and different key; thus, the key required to de-crypt the newly encrypted DCP is owned by the archive, and can be securely stored and conserved.

Although I am personally uneasy with the idea – as any extra layer of complexity increases exponentially the probability of problems – an archive could even decide to store encrypted DCPs, as long as it owns the keys it produced with the procedure above.

Whatever the strategy of the archive is, an "ingestion" station is basically what we all need to have in order to really manage a collection of D-Cinema elements and have a prayer of a chance of being able to preserve it.

Lesson Seven: Ingestion fine points: eyeballs, ears, perspicacity and persistence are essential!

A station that is designed to facilitate ingestion and processing of digital signals implies a group of equipment capable of appropriate procedures to ensure that incoming materials not only are what they say they are (the DCP opens, all the reels and the eventual subtitles are there, etc.) but that they are correct and the quality is what it should be. This includes a long list of checks (is it in the right color space, is the left eye really the left eye or do we have two copies of the right eye?), etc. Some of these need to be checked visually, and some of this would require some analytical automated tools to make sure that the MXF structure is correct, that the JPEG 2000 compression is within parameters and all the other little details where the proverbial devil hides. Similar considerations also apply to other digital formats, obviously.

I am not aware (my fault, possibly) of software that allows systematic checking of the packages we receive, but that's definitely something we all need. One could of course have a battery of servers and check each DCP visually on each of them, and it is true that all software/hardware do perform a check, and usually if something is wrong they either do not open the file or have some error message. But that's not really enough, nor is it practical or necessarily particularly significant in the long-term perspective (there might be minor errors that are not problematic right now, but they could become a problem later). What we really need is a piece of software that thoroughly checks a DCP to make sure that it is correctly done and produces a report that can be used as a record of the state of the DCP at ingest.

Last but not least, inspection inevitably entails some sort of 'visual' checking which is neither easy nor cheap, and right now it is more difficult than it sounds. Obviously, in order to properly check any digital format one needs displays that can show the required resolution, in the correct color space and that are highly reliable – in other words, a studio-level display. Never trust built-in computer or monitor down-res processes as they might either introduce or hide problems and errors.

Ultimately, the best way to check something that is designed to be projected onto a screen by a D-Cinema projector is to use a D-Cinema projector and a screen – the underlying concept being nothing new to a film archivist! But of course this is costly and poses some organizational problems as it risks creating bottlenecks because of limits to the number of screening rooms one can set up. Also 'studio' projectors are not exactly *that* small or cheap to buy and run. On the other hand, high-quality monitors capable of simulating a D-Cinema DLP projector's color space and gamut are also not cheap, although obviously they are more affordable than a projector and require less space. Whatever the solution, one needs a way to routinely check the displays' consistency and quality.

Another issue that should not be underestimated is the time factor.

Although we have a tendency to think that today a 250 GB file is not such a problem (and it is definitely a lesser problem than it used to be only few years ago), it still takes time to simply move it around, and it gets only worse when we try to move more than one at the time, or if we are dealing with DCDMs or DSMs that can be several Terabytes in size. Obviously, one can move files on hard drives on a 'sneakernet', but only in a very early stage. Very soon it becomes imperative to set up a proper network, and to factor the time required to 'move stuff around', as all post houses know all too well.

It can easily take one hour or more to simply upload a DCP from the hard drive it comes on into a server, depending on the interface and the bandwidth available. (By the way, this is going to be a serious problem with a cinematheque's typical programs of four different films per day, changing every day. In that scenario just having the files on the server becomes a problem.)

Lesson Eight: Make sure that the archive's staff has the required skills, competencies and know-how.

Already choosing, purchasing, and implementing what we discussed until now (metadata & equipment) requires some knowledge of the technology and of the technical solutions available as well as a sound understanding of the archival practices and principles as they are applied to a digital environment. Finding staff with the required skills and competencies is not an easy task and it is made worse by cinema being still a niche sector. Finding somebody with knowledge of video and even better, of Digital Video and/or Final Cut editing at a decent professional level, is possible, but finding anybody with a deep understanding of the cinema production, postproduction and distribution sectors is a serious challenge. (This might be necessary as the archive is bound to receive not only the 'finished product' – a DCDM or a DCP – but a 'bunch of digital stuff' that includes DSMs in the most perverse formats and files used in the postproduction process that need to be understood in order to be correctly checked and ingested.) Again this is not necessarily a new situation for archives, as they have dealt with all sorts of materials coming out of photochemical labs, usually mislabeled, mis- or not-described, etc., that needed to be sorted out. But of course archives have had decades to build up a staff possessing the required know-how in the analog domain. Re-training is of course a viable option and in most cases it can be the typical Hobson's choice, as hiring an experienced, highly skilled digital lab worker might prove to be unaffordable for most institutions. Besides, re-training might be the best option to make sure that your technical staff still knows what a film image look like, rather than coming in with a dreadful 'video look' in their minds.

Lesson Nine: Consider a separate IT team for archive work as opposed to layering it on a pre-existing IT group only familiar with office business requirements.

When thinking in terms of staff who need to adapt to the new world, one should not make the mistake of assuming that the regular back office IT personnel can handle it. Business-related IT is critical of course, and many public institutions have serious problems in this area, as way too many IT departments are only concerned with – and therefore competent in – office applications. Sometimes even installing and running new dedicated software in a large institution is a challenge as IT departments get nervous when things they do not control or master start creeping into their systems. It might make more sense to give up and just set up a parallel environment suited for managing and handling digital cinema content. But obviously, this might entail long negotiations and, inevitably, an increase in costs.

Lesson Ten: Get ready to retrain your film staff.

Although IT is of course the most critical sector, other parts of the archive must get used to new procedures as digital elements come in or go out: administrators must get used to the fact that 'delivery' might not be 'physical' anymore (they must be told what an FTP is, and this might be a challenge), print loan and distribution will have to deal with DCPs, programming will have to pose new questions besides "Is it 16 or 35?", projectionists must get used to the new, menacing and mysterious 'black box' in the booth. And so on.

Training of this kind is not impossible or complicated, but it is time-consuming and it implies a transitional period when mistakes are inevitable. Besides, it might require some flexibility, as it is to be expected that some people in the organization either refuse the whole new thing ("Digital? I just hate it!") or they simply can't deal with it ("Digital, I will never get it!").

In spite of everything I have just written, it must be clearly understood that what archives are faced with is not just a digital future – which would be easier, in a way. They are looking at an '*analog plus digital*' future, a future in which analog collections will co-exist with growing digital ones. This is less obvious than it seems. For one thing, it means that archives will have to manage mixed collections, they will need two sets of equipment, two sets of skills and experience, databases and collection management systems that can handle both as multiple analog and digital elements of the same title will co-exist, an analog *plus* digital projection booth, and so on.

Lesson Eleven: Get real: you're going to need more money right now!

The first, obvious and self-evident truth is that setting up for digital requires an increase in budget, and though eventual 'optimizations' and 'savings' might come in a second phase, the first phase simply will be one in which whole new sets of equipment from ingest to storage and projection will need to be acquired and put in place, as well as new skills and new staff.

As is always the case in the media and cultural environment, the advent of a new technology and the establishment of systems for its preservation (social structures, institutions, technologies, etc.) are not synchronous events. So it should not come as a surprise that while many governments in Europe are directly or indirectly supporting and encouraging the digitization of cinema exhibition, there is no comparable effort in supporting the preservation of the works produced for D-Cinema distribution. The danger is that we implement solutions only post-factum, which would result in a certain amount of losses – again, nothing new for archivists, just something we are not so excited to see happening yet again!

The above does not mean that archives are not working and getting ready for that, and apparently something is moving at a higher political level. The European Commission recently launched a study on the "challenges and opportunities for film heritage institutions in the digital era"[x] that should result in a set of very concrete and practical recommendations on the "legal/organizational/technical changes [that need] to be introduced to make sure that archives will continue to perform their role in the digital era." Translated from the political jargon, this represents a first attempt to deal with these issues with a system-wide approach that might even produce significant and meaningful results (I know, I am a die-hard optimist).

As a matter of fact, the shift to a digital world from capture to exhibition impacts most areas of an archive's activities, and therefore a systemic approach that takes into consideration many aspects of the problem is indeed welcome. And even more welcome is an approach that does not take into consideration only the short-term perspective but factors in very long-term scenarios as well.

Lesson Twelve: Consider the *future* future.

Much of what I have written so far speaks only of the short term. The picture gets more complex when we consider things in the medium to long term. The following is not listed in a precise order; nor will I comment on all of them. Approach this as "just thinking out loud."

Worry #1: Until now, I have referred to the challenges of managing, ingesting and preserving D-Cinema elements, while in reality the very first big problem is *acquisition*!

As the most common D-Cinema elements are encrypted DCPs, one thing is sure: there won't be any 21st century Dawson City. There won't be any more Dawson Cities where long forgotten prints are recovered after decades spent in the permafrost; nor distributors depositing positive prints to make space in their vaults; nor prints left in a booth, nor labs depositing prints and inter-negatives left on their shelves. In short, fate won't play a role anymore in an archive's acquisition policy. Prints will not 'turn up'.

While legal, contractual and voluntary deposits are the most important reasons for acquisitions, we must face the reality that it was fate, haphazard, serendipity, whatever you want to call it, that brought into the archives all those prints and negatives that were forgotten and abandoned in the many dusty corners of the analog cinema industry. Like Dawson City, for one….

Serendipity is not going to play a role in a digital world, as what is more likely to be found is an encrypted DCP, of which the key is long forgotten, lost, or belonging to a bankrupted production company.

It might be different in countries where the film industry is stronger and better structured (namely the US, possibly India) but in most European countries, for example, the reality is that production companies come and go, are dissolved or go bust and budgets are too small to ensure regular payments to any commercial film storage company, let alone a digital repository. In an analog world, most of these forgotten film elements would eventually end up in an archive. At that point, the films were safe from loss, and the archives' problem was to locate the rights-owners, as companies dissolve, names change, widows and daughters get married, etc.

As for now, the problem will be to find out who was the last to hold a key. And if we get to that point, we can be sure that the percentages of what we lose would make the loss of silent cinema works look like a picnic.

Worry #2: Truth is that behind any deposit or acquisition of a digital element there will have to be a *conscious* decision. There are many different reasons why such a decision could be taken. Some countries have legal deposit schemes, while others impose the deposit of works whose production was supported by public funding and so forth. Hopefully voluntary deposits will continue, as I think they are to everyone's advantage.

Right now, in many cases commercial vendors do not charge for keeping a DCP on their tapes or disks, because their business model is that the fees they collect for making copies and KDMs will pay for the storage. But we all know very well that when theatrical distribution is over there is very little use for projection elements. This used to be one reason why prints were deposited in archives: to save storage costs and headaches. This is in fact one of the many ways by which archives have been actively supporting the film industry for decades.

In the digital era, the real question will be: how long will it be until a service provider will realize that after two or three years a DCP (even more so anything bigger than that) will only be a liability and a responsibility and will cease to produce income? If this is already true in the analog world where storage is basically passive, how soon will the storage of digital materials entail regular migrations and become a really significant cost factor for laboratories and owners of the elements. As archivists, how often have we received in deposit printing elements long forgotten in a lab and whose storage the owner stopped paying years ago? But don't worry: no need for that anymore, a simple "format disk" command would do.

In this scenario, preservation of digital elements must be based on a new level of collaboration between archives and the industry, a collaboration that needs to be even closer than what we already experience now. For the industry, this means realizing that fundamentally different from any other player on the scene, archives' *only* interest is long term preservation and they have been doing that for many, many decades, in good times and – more importantly – in bad times.

Worry #3: For archives, this also means that they must not only implement long-term preservation strategies, but they also must implement serious steps to make sure that the materials are securely stored with no chances of unauthorized access, without which of course nobody would ever deposit anything with them – at least nothing that could be preserved (i.e. nothing unencrypted).

Yet again, the principle of storing items safely and securely is not new, nor has it changed. It is the concrete methods, procedures and technologies that change. Let's not forget that archives have been storing unencrypted formats for decades: they were called 'release prints' and 'negatives'.

Worry #4: Analog collections will continue to exist and will need constant care to be properly preserved. That's true, but they will inevitably change their status and function.

Once theatres will all be digital, the viewing prints we hold in our vaults will be projected by us. We will be the only ones left able to project analog prints.

Next, photochemical labs will become too expensive and unreliable, their quality will decrease as their staff ages and retires and maintenance gets too costly. Ultimately, they will be gone too. This is not something bound to happen in the distant future, this is something we are all experiencing already; large areas of the world do not have easy access to film lab services today.

When photochemical labs are gone all the prints in our collections will become irreplaceable and unique. They will be irreplaceable because we won't be able to make new ones, and unique because at that point all prints will be the only witness of the way the work originally looked and sounded. Suddenly, every item in our collections will be a unique *master*.

Inevitably, this will have an important impact on strategies and procedures (for collection and storage management, preservation priorities, access limitations, even vault design) that we used for decades and were based on a hierarchy in the collections that now will have to be redefined.

This process will take some time, how much exactly depends of course on a number of factors, including how fast the industry in your country will switch to digital distribution, how resilient Kodak and Fuji are, whether your archive has its own internal lab or not, how good your staff is at keeping it in operation, etc.

But the process of reconsidering your collections will start very soon. The day when you realize that there is almost no theatre in the country that can show all those beautiful prints you conserved so carefully and no lab to make a new one, that's the day when you start looking at them in a completely different way. That's tough, believe me.

Worry #5: As much as I am concerned with the problems of finding new staff members who are competent in this whole digital world, as much as I find it difficult to find skilled and not-too-greedy IT

staff, as much as I struggle to decide which equipment to buy, where and how to install them, and how to train my staff to use them, still I have a discomforting feeling that this is not the hardest challenge yet, at least in the medium term. No, the challenge of the future, the real problem for future archivists will be analog.

And it will be the real challenge because all the knowledge, the know-how, and even the technology on which the analog film industry was based is already fading away, and soon it will be gone completely. Again, it is not a matter of whether or not, it is a matter of *when*.

As a matter of fact we have been witnessing this trend for quite some time. Since films are post-produced digitally, negative cutting, optical printing, and even grading are all activities of the past; if and when they survive, it is mostly for archival works, not for production. The technology of film-based production itself entered its sunset quite a few years ago, with no new research or new products being introduced in quite some time. The years since the last printer or analyzer were designed are counted in dozens. And the lab's staff is definitely ageing, as no new staff is hired or trained. Departments are being shut down, not opened.

Film labs barely survive on the production of positive prints off 'digital negatives' and some negative processing. Most if not all of them have opened new Digital Intermediate departments and some might even convert completely to digital. There is no doubt in my mind that analog film services will shrink to a handful of specialized labs serving only the commercial or non-profit archival market or the production of film-based protection materials. In the best of scenarios, wet labs will become a highly priced niche market which will progressively dwindle to nothingness when analog film technology slowly fades out or is replaced with a non-film-based archival media which truly does have 100 years or more useable life between migrations. In the worst-case scenario, labs will go very fast if the bulk of their business depends on positive printing and processing.

In the short run this might even turn into an advantage for archives, as many good film lab technicians and truckloads of equipment will become available, almost for free. It may be valuable for archives to seriously consider the option of buying the closing labs and keep them running if they want to have film services for few years more, although operating them in this 'Omega Man' scenario will be neither easy nor cheap.

So, while it may be true that job offers for film technicians might continue for a few years, after this wave there will be nothing. Those of us who teach at universities know all too well that nowadays talking about anything analog to the students is like speaking Martian: there is no connection, no shared experience at all, blank stares or at best, fetishistic fascination.

Obviously there are still students interested in archaeology, and they can be taught about 16mm and 35mm, negative and positive, about archiving and managing analog collections. It will be hard and costly, but this can be done.

Worry #6: What really worries me are "the eyes."

There will be no *eyes* left which have the experience of seeing a film projected onto a properly-sized motion picture screen, or if they see a motion picture image projected by a film projector, it will be in a laboratory environment, not in a good-sized theater with a substantial audience.

They will watch guinea pigs run and think they know what a lion is.

This phenomenon is already underway and it is creeping up to our screens: if you look at recent digital restorations you will notice how many of them have that clearly distinguishable, unpleasant, artificial 'video look', not even close to the look and feel of a film work.

I am afraid that these are just symptoms of the hard times ahead, when managing our analog collections will be much harder than managing our digital collections. It's hard to believe when we look at short term challenges, but it's nonetheless true.

Worry #7: If analog labs are bound to disappear or to become a niche sector serving only the archives, I think digital labs are also going to face a restructuring whose early signs we can already spot around the world.

Technical evolution in the IT sector has largely reduced the gap between high-end equipment used for Digital Intermediate and the prosumer mass market. Today it is absolutely possible to install a full DI workflow in dad's playroom in the basement. The only obstacles to complete the workflow are of course scanning and film out. Oh, sorry, I forgot: film out won't be needed anymore. Scanning…. Well, scanning demand is already going down in the high end market, as movies and even more so when medium to low budget TV series are moving to HD. And medium to low budgets productions are important because they constitute a significant portion of the market. They are the first to experiment with cheaper solutions (dad's basement playroom) and in the past they were often served by the same labs who provide the archives their restoration services (as the big labs usually have other fish to fry, like big budget movies and series). It is not difficult to see that a possible scenario for the future is one in which very few large labs are surrounded by smaller and sensibly leaner ones with few workstations and few operators and absolutely no scanning capabilities. A scanner is too expensive and a risky investment as its commercial life is expected to be short. After a few years, maybe less, its only market will be archives, and they are famous for not paying much per hour or per minute.

Worry #8: I am seriously concerned that the decreasing demand for scanning services on one hand and the overall restructuring of the laboratory sector on the other will sooner or later result in a slow but unstoppable decline for the whole scanning technology, much like what we experienced in the analog film technology domain. Actually, I am not really worried that this *might* happen; I am sure it *will* happen. Again, it is just a matter of time.

Obviously this won't happen overnight as there are enough BTS Spirits or Cintel C-Realities around today that can be kept alive. But I wouldn't bet on a new scanner being introduced in the market any time soon or many more to be purchased outside of archives.

Ultimately, I think it is inevitable that scanning will become a niche market with machines built only for archival work, which will result in either a decline in quality or an increase on costs, most likely in both.

And this is my closing remark on why I think the real challenge we are facing is analog and not digital, as we are led to think by its sheer, overwhelming momentum in today's moving image world. The shift to digital will be really complete when all productions use digital capture. It will be a whole new world, a world in which any film-related technology including scanning will be gone for good, and the competencies and skills in the field will be decimated.

Now, before the Editor hits me on the head to make me stop wasting virtual trees, I'll leave with a closing remark:

Not discussed in the context of this article are the many technical issues, techniques and choices that we all will face when it comes to digitizing (and/or digitally restoring) our analog collections. Add to that the largely unexplored issue of how to correctly simulate an analog projection in a D-Cinema environment. It is not an underestimation of the problems but a conscious choice for me to hope that each of the various challenges we are facing are big enough to be treated separately, as I hope they will be, in future issues of this Review.

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[i] "FIRST-Film restoration and conservation strategies" was a project co-funded by the European Union that ran from 2002 to 2004 and published a Final Report titled "European Film Heritage on the Threshold of the Digital Era"
[ii] Digital Cinema Initiatives, LLC (DCI), see http://www.dcimovies.com
[iii] NDIIPP – National Digital Information Infrastructure & Preservation Program (www.digital preservation.gov)
[iv] "EDCine – Enhanced Digital Cinema" was another European project and it was focused on D-Cinema technologies. One of its goals was to devise ways to preserve D-Cinema elements.
[v] Technically speaking: "ISO/IEC 15444-1:2004/Amd 2:2009"; they can be purchased as a document here: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=52174
[vi] The recently published standard allowing silent frame rates was recently published and it can be obtained at http://store.smpte.org/product-p/st%200428-21-2011.htm

[vii] The document can be found here: http://www.fiafnet.org/uk/publications/fep.cfm
[viii] Quote from the FIAF TC Recommendation
[ix] Arne Novak, "Digital Cinema Technologies from the Archive's Perspective" on this Review
[x] The study is undergoing and should publish its results at the end of 2011. More information can be found at www.dae-filmheritage.eu

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From the Association of Moving Image Archivists

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Musings on 500 More Years of Film and Digits

By Ken Weissman

You will recall that in *AMIA Tech Review - Issue 2*, I provided details of the Library of Congress film preservation program. Building upon that article, you will also recall that one of the main missions of the Library is to preserve America's memory for future generations of Americans, with no defined end point. The goal is to have our moving images and the sounds associated with them available for our grandchildren's grandchildren and for as many generations beyond them as one can imagine – literally for hundreds and hundreds of years.

There has been a lot of research on the long-term storage of motion picture films, so the issues surrounding the deterioration of that media are pretty well defined and understood. While you'll find some people taking issue with that research, most people agree that under the proper storage conditions, a film will still be around and usable after 500 years or longer. The storage environment needed to achieve these life expectancies is relatively modest, somewhere in the neighborhood of 40 degrees Fahrenheit, 30% relative humidity. None of this is currently very controversial, so let's accept this as one of our starting points.

Further, one of the beauties of film is that the machine it takes to look at the images is amazingly simple. All you need is a light source, a transport mechanism, a lens, a screen and voilà, you can see moving pictures. Neither the technology nor the expertise to recreate it is ever likely to go away. Contrast this with hard drives or other types of digital storage. You can't look at the files in and of themselves, and you will need a lot of technology to bring the images back for viewing.

We are now at the dawn of a new era where the preservation of these images and sounds might be accomplished using digital methods that successfully capture all of the resolution inherent in the original film elements themselves. Theoretically these digital copies will then be managed by tried and true information management migration techniques that ensure that the contents will always be available even as the technology to access them continually improves and evolves.

So let's ask ourselves some questions. Perhaps the first should be: how long do we keep the film elements themselves after we have made digital masters from them? Well, it seems we first need to define the issues before we can even begin to answer that question. So what are they? Certainly the goal of keeping the images and their associated sounds safe and available for future generations is an issue. Some films are also valuable as artifacts while others aren't, so we may need to save some for an even longer period of time. For the sake of sanity in this discussion, let's put a 500 year limit on it. This is the equivalent of some 50 to 100 migrations of the digital data. We should know by then if we are doing digital right!

While maintaining our traditional photochemical workflows is important, we recognize that digital scanning for preservation purposes makes sense and so we need to plan for a future without film. As mentioned in the last article, our first foray into that world involved a specialized project that targeted the Paper Print collection. We learned a lot from that pilot project and now feel confident that digital scanning of films and other images has matured enough for it to be considered a preservation quality technology. But we remain cautious.

As our lab moves further into digital technologies, the plan (for now) is to scan the images from only a small subset of all the films that make their way into our film preservation laboratory, and then to preserve the scanned files or restore those using digital tools as needed. For an even smaller subset of those films, we will record them back to film, and put them away into cold storage at 25 degrees, 30% relative humidity where they should last practically forever (2000 years +). Our reasoning for this is pretty simple: we can make high quality film-to-film preservation masters along with access copies for viewing in our reading rooms or for use in our loan programs much faster and much cheaper than we can currently achieve using digital methods. This is likely to continue as long as motion picture laboratory raw stocks are available for purchase.

Our cautious nature aside, we recognize some of the inherent strengths of digital workflows, just as we recognize the weaknesses. In digital you don't have the degradation you get from even the most controlled processing when you go through *multiple* generations of analog film-to-film duplication. Actually you don't have to go through many film generations at all before the generation degradation becomes noticeable to even casual viewers. Clean up of dust, scratches, and even tears is pretty straightforward using digital techniques and these techniques are becoming more and more automated. With digital, stabilization of images is a snap, as is recreating tints and tones often found in silent era films.

But if we consider *staying* in the digital realm, we should ask ourselves, "What happens if we don't do film-to-film transfer as the main preservation workflow any longer? What's the impact going to be on the amount of data we create and our ability to handle it? What about our digital infrastructure?" This is when the numbers become really, really scary.

Speaking very broadly, with 4K scans of color films you wind up in the neighborhood of 128 MB per frame (including an IR channel “dust map”). Figure that a typical motion picture has about 160,000 frames, and you wind up around 24 TB per film. And that's just the raw data. Now you process it to do things like removing dust, tears, and other digital restoration work. Each of those develops additional data streams and data files. We’ve decided, based upon our previous experience, that it is best to save the initial scans as well as the final processed files for the long term. Now we are up to 48 TB per film. In our ***nitrate*** collection alone, we have well over 30,000 titles. 48 TB x 30,000 = 1,440,000 TB or 1.44 EB (exabytes) of data. Just in case you were wondering, this is another reason why we don’t plan to scan everything!

One of our IT people was asked about the data impact if we were to digitally preserve a typical feature film. A typical scanner might have 5 to 10 terabytes of direct storage associated with it. Once you fill that, then you have to offload the media to a *Storage Area Network* or SAN for post-processing and then, once you're done with post-processing, you have to put the data into a deep archive. If you want to do anything with it later on, you have to pull it back out of that deep storage archive.

The process of pulling out a single terabyte of data from the deep archive obviously depends on the speeds of the digital infrastructure. But right now, I’m told that moving one terabyte from our robotic tape-based system to a SAN, where we could do some more processing on it, would take between 3 to 5 hours to complete -- and that's with 10 Gigabit interfaces. The numbers are staggering.

Everyone is pretty much agreed that you should migrate that data after five years to the next latest and greatest thing or you risk losing it. And of course, you want to have a backup copy. I've even been at several conferences and meetings in the last couple of years where people are saying, "No, no, no, no, you want to have at least TWO backup copies.” On separate servers, separate geographic locations, the whole bit, because a single backup that you make might not be able to be restored. You want the second backup, just in case.

And you’ve committed to migrate it all, every five years. That’s not going to be cheap.

There have been conversations recently among AMIA members weighing what it would actually cost to store a film for 500 years versus migrating data for 500 years. There are legitimate arguments on both sides, but suffice it to say that cold storage, 48 degrees and 30% humidity, costs money too. It’s not necessarily simple to do that for 500 years.

There may be no way that you can actually calculate it, but I can’t help but feel in my heart of hearts that the simple solution is usually the best. And film is a pretty simple solution.

We have had a very robust preservation program over the years, and we still have a long way to go. We have only been able to restore a small percentage of the films that we are preserving, and we're collecting new films all the time. We acquired a privately owned collection of films about three years ago that added almost 15 million feet of nitrate film to our collection, and we are currently negotiating for another of similar size.

In the meantime, we have our prototype project for digital archiving in place, and we are moving forward from there. But we also realize that we might need to be the last film lab standing, and we're fully prepared to be that as well!

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PBCore: The Challenge of Adopting a Descriptive Metadata Standard for Public Media

By Nan Rubin

When all full-power television stations in the U.S. turned off their analog transmitters in 2009, the all-digital broadcast chain was complete – from recording at the start of production, through editing, production and distribution, to viewers with smart phones, VOD, and other platforms.

With this digital environment looming, in 2001 the Corporation for Public Broadcasting (CPB) convened the Public Broadcasting Metadata Dictionary Project (PBMD). Comprised of engineers and operations personnel from radio and television stations, their task was to adopt a single set of metadata protocols, to be known as the "Public Broadcasting Core (PBCore) Metadata Dictionary."

Given the constant introduction of new broadcast equipment, they understood that a *single* metadata standard was necessary to facilitate interoperability by a wide array of devices among such different users as stations, distributors, producers, and vendors of traffic, DAM and related systems. And while not explicit, it was thought that the standard would also become important for archival materials as well.

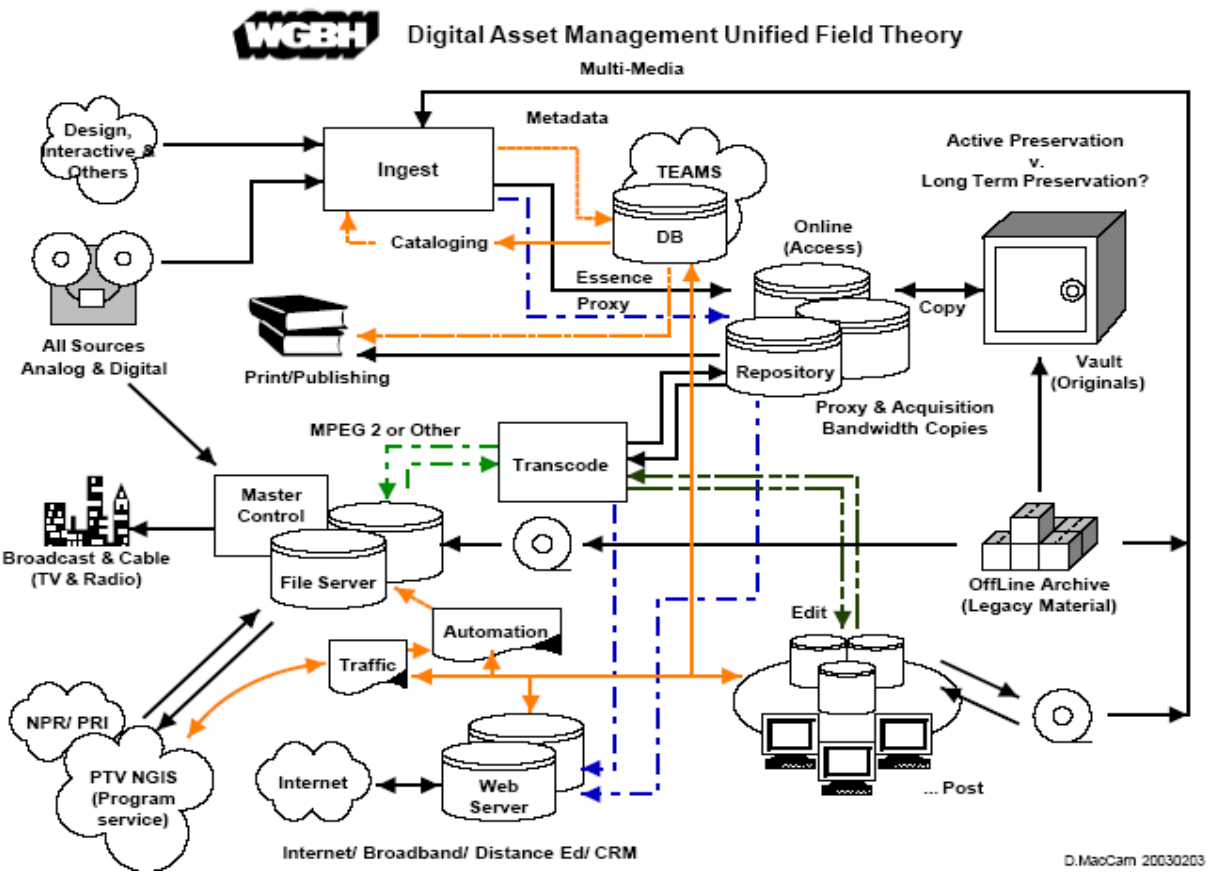

Figure 1
Internal Broadcast Station Workflows
(Credit: Dave MacCarn, WGBH, 2003)

Because metadata is fundamental to the exchange of digital files, the intent was to identify a core set of descriptors for the digital content used at most public radio and television stations. The Project spent more than two years studying digital operating systems and examining various metadata dictionaries, in particular those used to describe subjects as well as administrative and educational aspects of rich media. The goal was to arrive at the smallest set of elements that could adequately describe and catalog program files.

Dublin Core Element Set[i] emerged as the most appropriate to meet these various concerns, and *PBCore* was devised as an application profile built on Dublin Core but that also retained elements from other schema and station-based asset management and traffic systems. The end result was a set of metadata standards with a solid foundation that is extensible, scalable, and easy to understand.

PBCore was intended to be "simple" but not "simplistic," because the schema had to be easily understood, implementable and acceptable to the public broadcasting community at large. PBCore contains 58 elements organized in three categories:

- **Content**: 20 elements describe intellectual content of a media asset;
- **Intellectual Property**: 9 elements relating creators and usage;
- **Instantiation**: 29 elements identify the media asset as it exists in the physical world or digitally.

These, in turn, are organized by Content Class, each of which consists of Containers holding individual Elements.

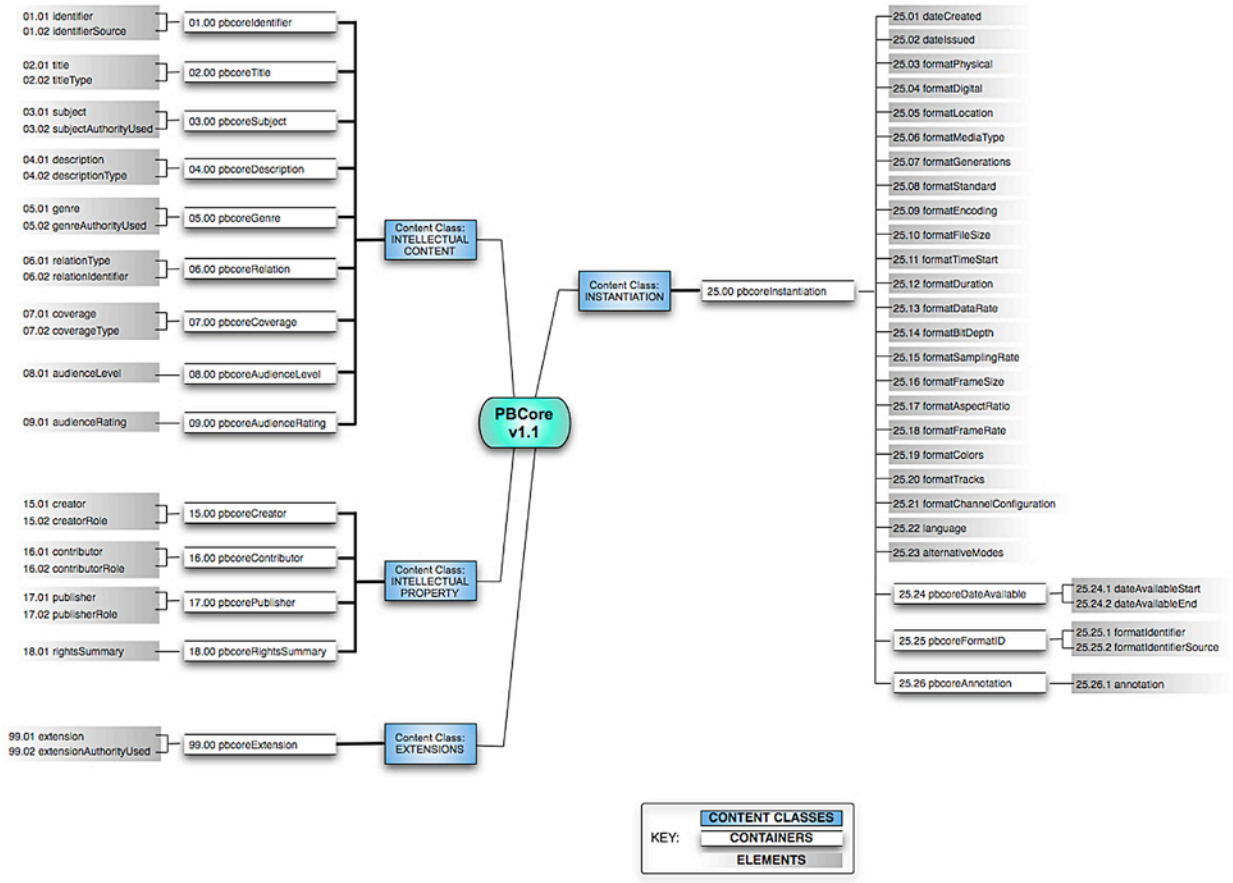

Figure 2
Schema: PBCore v1.1

The PBCore 1.0 was published in spring 2005. It was presented as a single, streamlined standard to which other database structures, including those of PBS, NPR, major producing stations and other asset/content management systems, could be mapped.

PBCore was especially useful for describing digital media, including file URLs for streaming or downloading, and as a syndication format like RSS or ATOM. It was also considered useful for launching an archival or asset management system, because a complete PBCore record contains metadata on the provenance of an object plus the location of media "instantiations" – for example, recording that a media asset is published on the internet in addition to recording the file location and ownership of its source.

In this form, PBCore worked as a basic "starter kit." However, it was recognized that v1.0 would require improvements once it began to be used. Adding extensions to the existing set of metadata elements was planned to accommodate such practical needs.

PBCore.org [http://pbcore.org] was established as the primary reference site. After its release, there was slow but uneven acceptance across public broadcasting, especially as stations increased the content being offered on-line, such as audio and video clips.

At the same time, PBCore was discovered by moving image and media archivists as a useful cataloging format for film and video. From 2005 through 2008, PBCore sessions were presented widely at conferences such as AMIA, the National Educational Television Association, the annual PBS Technology Conference, and similar gatherings, which spurred interest in its use far outside public broadcasting.

PBCore began to be treated as an "access and archival media" metadata standard. *PBCore Resources* [http://pbcoreresources.org] was created by an active user group as an "unofficial" website to encourage user collaborations. The informal site has become a primary sounding board for users to share experiences testing and implementing PBCore in a variety of environments.

Another group built an online "PBCore database." Powered by Ruby on Rails, Apache Solr, MySQL, nginx, and other third-party modules, the 'PBCore Repository Tool' (as it has become known) is an Open Source application available for free downloading at [http://pbcore.vermicel.li/]. This public repository holds examples of 1200+ entries, and the cataloging tool can generate records in XML or in a standard viewable format.

In 2009, CPB began planning *The American Archive,* a new initiative to organize and preserve 50 years of public radio and television programs. It was especially notable that the very first

project of *American Archive* was to re-establish support for PBCore and continue its development after several years of being dormant.

A requirement for programs accepted into *American Archive* will be that records be PBCore compliant. Based on this need, Version 2.0 was released in January 2011, with technical assistance from AudioVisual Preservation Solutions[ii] and Digital Dawn. Changes incorporated in v2.0 were based on recommendations collected from a wide range of users after broad outreach and feedback. This new and improved version can be downloaded at: [http://pbcore.org]

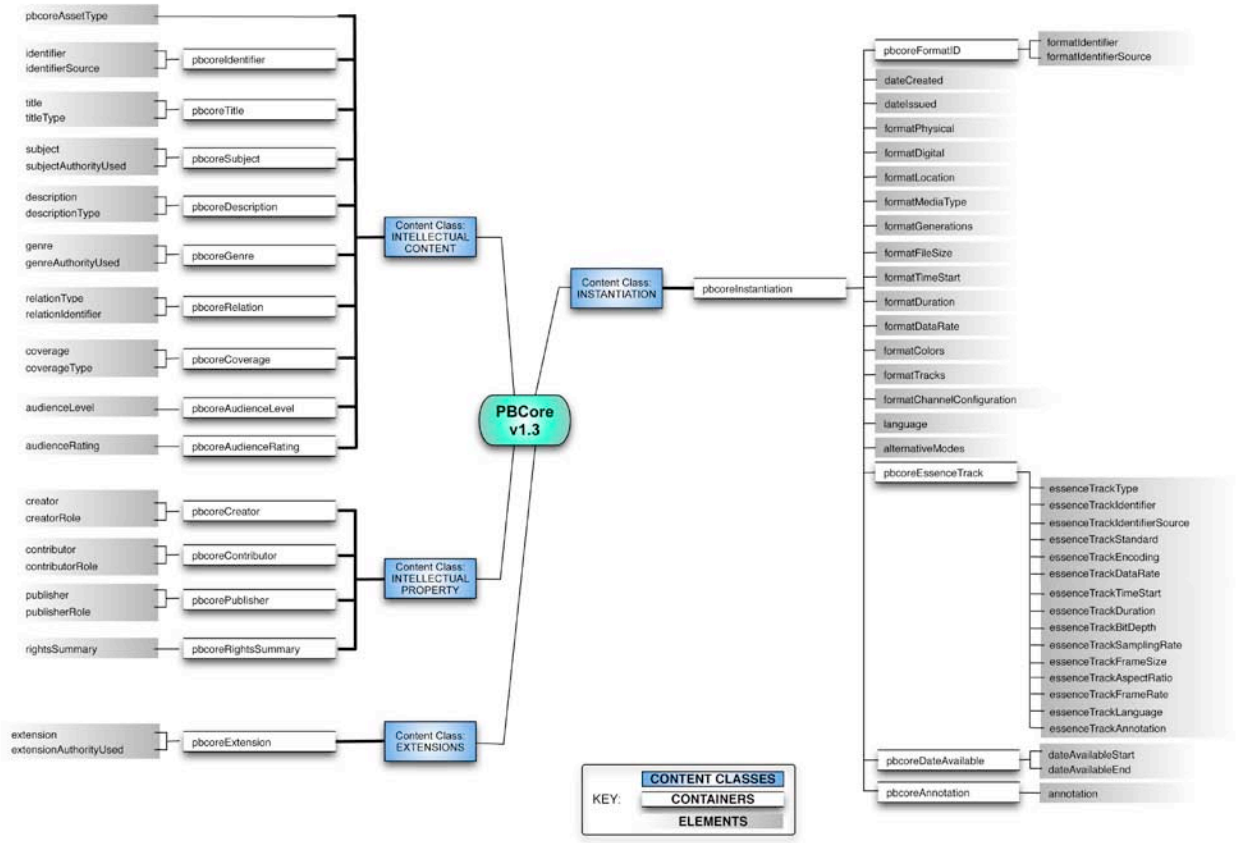

Figure 3
Schema: PBCore v1.3

Many stations and producers are starting to look for guidance on metadata, especially to manage their burgeoning sets of digital program files. The evolution of PBCore over the past

five years has relied on active participation of an expanding user community, and as PBCore improves, each year new institutions are discovering it, such as Dance Heritage Coalition, Northeast Historic Film, and stations like WILL TV & Radio, WNET-TV and WNYC Radio. These groups reflect a broad array of media producers and collections, and in response to a growing market, new open source and vendor-provided PBCore tools are also becoming available.

However, among public broadcasters, it is still not universally understood that digital media files require standardized metadata to remain useful over time. The question, "What is PBCore for?" continues to be raised, especially if a station already has a functioning media database.

With release of v2.0, the momentum for adopting PBCore will continue to build. We hope it continues within public radio and television, where the investment was made on behalf of a system that needs a descriptive metadata standard now more than ever.

FOOTNOTES

[i] **Dublin Core Metadata Element Set, Version 1.1: Reference Description.**

October 31, 2010, from http://www.dublincore.org/documents/dces/

[ii] **AudioVisual Preservation Solutions,** Retrieved November 11, 2010
http://www.avpreserve.com/

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A Single Track on the River Kwai*

By Bob Heiber

"When the legend becomes the fact, print the legend." – Maxwell Scott

This famous quote from John Ford's classic western film *The Man Who Shot Liberty Valance* is also classic for other reasons. When great motion pictures undergo image and sound restoration the facts of their origins, like original picture aperture and track configurations can become lost. The 2011 Blu-ray/DVD release of *The Bridge On The River Kwai* is a recent example of the legend becoming the fact.

Remastering classic motion pictures for image and sound is nothing new. In 1954, David O. Selznick revisited *Gone With The Wind* to remix the film with a Perspecta-Sound soundtrack. However, with a release date of 1939 the film's soundtrack origins as monaural could never be in doubt.

For *The Bridge On The River Kwai*, released in 1957 in the CinemaScope® format, rumors about a stereo sound track accompanying that release have eddied around the film like currents on the River Kwai. Some of these rumors undoubtedly stem from Director David Lean's reputation for making wide-screen, stereo-sound blockbusters. Also lending seeming credibility to the legend is the existence of a stereo sound track on the 1994 home video release. The '94 home video track was the result of an abandoned 70mm, 6-channel stereo sound track remastering project for *Kwai* done in 1991.

For the recent 4K image restoration and release on Blu-ray, some disc reviewers once again perpetuated the stereo legend of *The Bridge On The River Kwai*. The fact is the new BD/DVD and recent limited theatrical showings have used the 5.1 re-mastered version produced in 2000 under the supervision of Grover Crisp, Sr. VP Asset Management, Film Restoration and Digital Mastering at Sony Pictures Entertainment. For that project, the audio underwent an extensive evaluation, which undisputedly resolved *Kwai's* mono origins.

Though the film did not have any major re-release in 1991, the work of picture editor George Hively, sound editor Don Hall and re-recording mixers Tennyson Sebastian, Joel Fein, and Bob Minkler provided pivotal sound elements for the subsequent work in 2000. The decision to revisit the 1991 stereo sound track was due to several factors.

The fact that the mixers created a 70mm 6-track, Left/Baby Boom/Center/Baby Boom/Right/Surround version to accompany a planned 70mm release meant that the "baby boom" channels contained frequencies up to 250 Hz, including music score content. The LFE (Low Frequency Extension) channel for a modern 5.1 soundtrack is usually restricted to frequencies below 120Hz, so creation of new LFE content was necessary for the 5.1 discrete multi-channel stereo presentation.

Also, the reader should be aware that in 1991 sound mixers did not have at their disposal some of the digital tools commonly used in sound re-mastering today. Digital processing systems and editorial methods to reduce distortion and optical noise, pops and clicks were not as readily available then as they are today. Thus, for the current release, there was an opportunity to revisit and improve on some of the work that was done to address noise issues present in the original mix. However, the sound work prepared for the 1991 version provided important sound elements and information for the remastering project of 2000.

In 1991, after inspecting the entire sound element inventory - about 260 single stripe magnetic film reels - editor George Hively and sound editor Don Hall proceeded to make new 35mm magnetic preservation copies of the original separate mono Dialogue, Music and Effects (DME) reels. Their goal was to provide as complete an original DME track for the Sony mixers as possible. However, since many of the acetate reels were more than 34 years old and suffered from vinegar syndrome (displaying both shrinkage and curling), portions of the dialogue and effects had to be taken from optical tracks. Thankfully, all of Malcolm Arnold's Academy Award®-winning score was recovered by the Sony editors.

For the 5.1 re-mastering in 2000, engineers made extensive use of the mono preservation transfers and pre-mixes made in 1991. The element inventory was well-labeled and well-documented, which made it possible to efficiently identify and access the needed reels. After evaluating and comparing the 1991 6-channel version, a mono 1957 print and the mono magnetic dialogue stems, it was evident that the magnetic stems would yield the best quality. It was also determined that the 1957 composite track would be used, much the same as in 1991, when the stems were incomplete or would not yield good quality. This occurred in several sections.

To get the project started, 104 reels of 4-track dialogue, effects and music pre-dubs were organized and transferred. These 35mm, 4-track mags contained the 1991 mix of the dialogue, effects (both original and library augmentation), backgrounds (also original and library), and mono music.

Since the production dialogue was predominately mono on the 4-track stem, it was loaded directly into a NoNoise® workstation to be synchronized and cleaned up. The 35mm mono music units also received the same NoNoise® treatment. In several sequences in the 1991 work it had been noted that the mono music appeared to be alternate takes, as it did not sync with the 1957 composite. However, using editorial and digital time manipulation programs, the score was adjusted to more closely match the composite.

While the dialogue and music tracks were being processed, conform engineers were busy pre-laying the 1991 sound effects and foley tracks to be certain that all of the 1991 work would be available for the 2000 remastering. Minor flaws found in the tracks were also repaired prior to the mix. As the cleanup work was going on, Chace Digital Stereo® cues were designed for the 5.1 remastering. By having seven inputs available on the CDS processor, the entire variety of formats - mono, stereo, or LCRS (left, center, right, surround) - could be incorporated. Using the CDS processor, 5.1 stereo backgrounds were created from the original tracks during the mix. The stereo backgrounds helped to eliminate edit anomalies and blend ADR with production dialog.

Yet with all the tools assembled, great care was taken not to change the true character of the mix. Filmed on location in Ceylon under difficult circumstances, the background noise of generators and insects are often indistinguishable and thus become the sound of the camp and its oppressive environment. With a few slight adjustments, the 5.1 soundtrack created in 2000 was the track used for the 2011 Blu-ray release of *The Bridge on the River Kwai*. Considering the careful examination of all of the elements which went into the 2000 restoration, there is no doubt of its monaural origins. Hence, it's time to put the "Legend" to bed!

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*Editor's note: The real bridge over the Kwai River in Thailand supports a *single* narrow gauge railroad track!

AMIA Tech Review
From the Association of Moving Image Archivists

April, 2011 | Issue 3

Introduction

The following article is presented as a tutorial for AMIA members. While it describes techniques and specifications for new finished audio soundtracks on programming intended for television broadcast which may include materials from your vault, please bear in mind that these techniques and specifications have not yet been passed into law in the United States. Furthermore, since most archives are not called upon to deliver finished, air-ready programs, these techniques will, if passed into law, be required of those who ***do*** *deliver the finished programs. As mentioned in the article, certain broadcast facilities are already requiring these specifications for their incoming, new programs and as time passes, other broadcast facilities may join them in these requirements.*

As a matter of historical note, you should be aware that manipulation of track levels by broadcasters is nothing new. Since the earliest days of analog broadcasting, automatic leveling was employed to restrict the dynamic range of audio as the final step of electronic processing prior to transmission. Perhaps the most exaggerated example of this was to be found in the 1950's production of "Victory At Sea" where, for the sake of maximum signal-to-noise during reproduction, the orchestral music track was recorded as loud as possible on the optical track and only lowered to normal levels when there was voiceover narration. The finished track depended on the transmitter audio limiters to bring the combined mix into balance.

More truly obnoxious examples can be found today when commercials are dropped into otherwise normal programming at levels (which by comparison) would wake the dead. It is this situation that the following article addresses.

Loudness Goes Legal

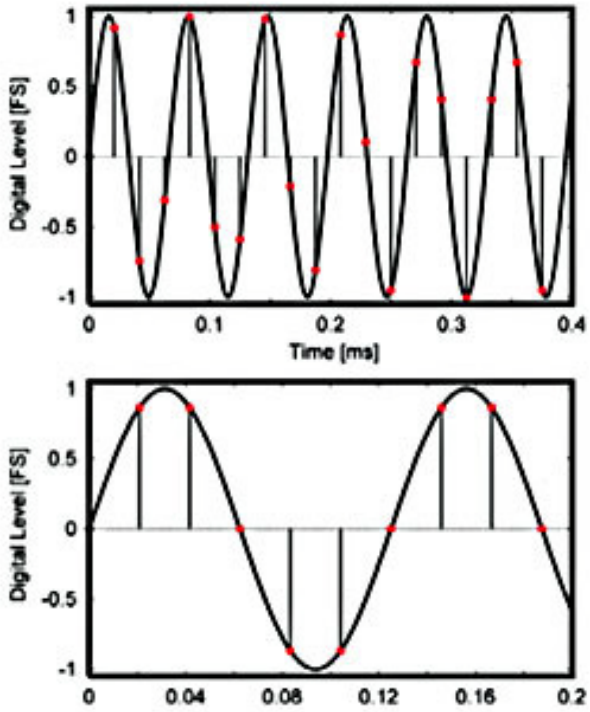
By Chris Reynolds

There has long been disagreement as to whether or not loudness can be measured objectively. Over the past few decades, countless tests have been conducted to come up with an accurate way to measure loudness as humans perceive it. Because volume preferences vary from person to person, it has been difficult to remove the subjective aspect of loudness measurement. Some people like their music loud, some like it soft. Some like explosions to shake their house while others don't want anything shaking at all.

Using information from various studies, researchers have succeeded in creating a new multi-channel loudness measurement algorithm that reflects how humans perceive loudness with an accuracy that was previously unattainable. The first version of this new algorithm was defined in an ITU (International Telecommunication Union) broadcast standard recommendation in 2006 (ITU-RBS. 1770-1). The new measurement scale is referred to as LKFS (Loudness, Kweighted (frequency weighting) relative to Full Scale).

The ITU recommendation also defines a new digital peak metering measurement system called "True Peak (TP)." TP allows for more accurate peak measurement of digital audio by analyzing the analog waveform derived from the digital signal. During digital-to-analog conversions, such as from a digital amplifier to loudspeakers, the peak level of the analog signal can actually exceed that of the measured digital sample peak, causing distortion and unexpected overloads in various stages of audio distribution and reproduction.

These are important developments for the providers of audio/video content because consumers are increasingly unhappy with the inconsistent levels they've been subjected to during digital television (DTV) broadcasts. In the days of analog television broadcasting, the audio tracks needed to have their dynamic range (difference between the quietest audio portions and the loudest program content) reduced. This meant that a lot of audio compression was applied to minimize the dynamic range between the quietest and loudest sections of program. The amount of compression that engineers used for this was not based on loudness, but on VU meter measurements and analog peak levels. This heavily compressed audio resulted in a normalized loudness level to which analog TV viewers became accustomed. However, it also diminished the listening experience. As DVD, Blu-ray Disc, and digital download/streaming services began delivering audio content with full dynamic range to consumers, it became clear that the analog broadcast system needed to be updated.

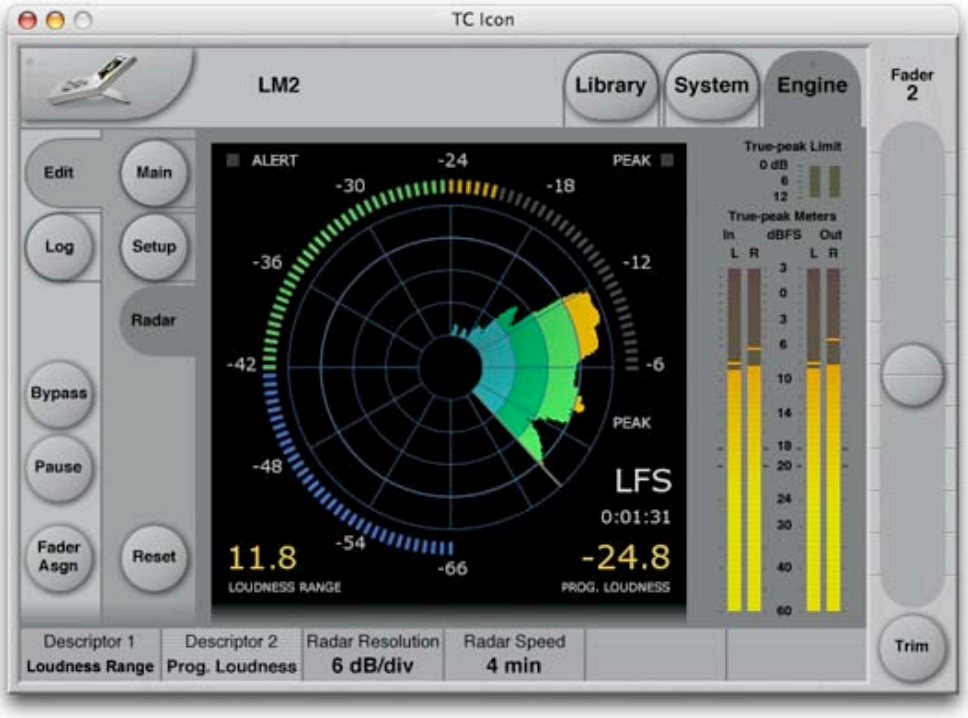


True Peak Graph: Digital samples (red dots) don't accurately capture the highest points in the analog sound wave (black lines), thereby necessitating true peak meters to calculate what's inbetween the samples.

That updated system is DTV, and it allows broadcasters to deliver more dynamic audio content while applying little or no compression. Unfortunately, it also highlights the level discrepancies between programs and commercials. Consumers vigorously complained to legislators that they constantly have to adjust audio levels up and down when watching television. Because of this, new federal legislation has been drafted requiring all broadcast audio to fall within a predetermined range. This legislation, named H.R. 1084 – also known as the CALM (Commercial Advertisement Loudness Mitigation) Act – has passed in both the House of Representatives and the Senate. After some minor changes are made, the CALM Act will surely be signed into law. The theory of this legislation is that if all programs are measured and adjusted to have the same overall loudness, consumer complaints over level discrepancies will decrease.

The CALM Act calls for compliance with a 2009 ATSC (Advanced Television Systems Committee) technical recommendation, A/85, which states that the "current version" of ITU-R BS. 1770-1 be used for all loudness and true peak measurements. Furthermore, it mandates that all broadcast material must have an average loudness of -24LKFS using dialog as an anchor point, and that the maximum level should not exceed -2dB TP (decibels true peak).

In order to meet these requirements, program material must be measured in its entirety for an average LKFS reading, after which the overall program level will be raised or lowered to achieve -24LKFS.



The EBU (European Broadcasting Union) has conducted its own loudness studies and agrees that the ITU-R BS. 1770-1 algorithms are very good, but it has also published additional recommendations to improve its accuracy and satisfy consumers. In addition to requiring a slightly different program loudness average (they're asking for -23LKFS as opposed to -24LKFS), it recommends intelligent gating processes and a maximum Loudness Units (LU) range. Based on additional studies, the EBU feels that consumers are interested in having more dynamic range, but not as much as A/85 allows. They advocate setting maximum LU ranges to minimize consumers' tendency to reach for the remote to adjust the level between programs and commercials. The ITU has been reviewing the EBU recommendation and is reportedly considering implementing many of the recommendations. As A/85 requires following the latest version of ITU-R BS. 1770-1, any updates based on the EBU recommendation will become law as part of the CALM act.

Just two years ago, taking these average measurements to comply with the CALM Act would not have been possible, but new audio meters are now available that contain both the ITU-R BS. 1770-1 and the EBU algorithms. Measurements can be derived, in real time, by playing the

program through the meters – or even faster than real time if audio files are used. Software can analyze the audio files and derive the measurements in upwards of 8x real time (about 15 minutes for a 120-minute feature).

While the CALM Act and the EBU recommendations have not yet become law, major networks in the United States and abroad (such as NBC/Universal and Sky Italia) are already requiring that content delivered to them conform to these new guidelines.

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Looking Backward:
An Introduction to Chapter Eight of "Moving Pictures, How They are Made and Worked" By Frederick A. Talbot, 1914

Mr. Frederick A. Talbot was an author of a diverse collection of books covering such varied topics as *The Railway Conquest of the World*, *Steamship Conquest of the World*, *Aeroplanes and Dirigibles of War* and *The Canadian Boy's Annual*, to name a few. In 1913 he wrote a book titled *Practical Cinematography and Its Applications*, followed in 1914 by the book presently under consideration, *Moving Pictures; How They are Made and Worked*. Mr. Talbot's forte seems to have been that of the intrepid observer, a generalist who in a less forgiving era may have been called an author of all trades and master of none. Be that as it may, his books on motion pictures have to be among the first to be published on this then relatively new and burgeoning field.

Chapter Eight of *Moving Pictures* recounts laboratory operations during that period in which motion pictures were exploding on the popular conscience and becoming very BIG BUSINESS. Undoubtedly taken from observations of average laboratory practice, the processes of developing negatives using techniques which have long been abandoned are well described. Though not explicitly stated – but obvious from our 21st-century vantage point – are the foibles of these techniques. The following highlights the source of certain flaws seen in negatives and prints from this period:

On pages 77 - 78, pay attention to the discussion of what is commonly called, "Rack and Tank developing." In spite of the methods described, rack and tank developing does not produce uniform development in a negative or a print. This can usually be seen as lightening of the image where the negative is wrapped around the end of the rack. The same effect is seen on a positive as a darkening of the image. In the projected image the defects are seen as a periodic change of density based upon the physical length of the rack and the depth of the developing tank. Watch for this "density bump" in the next early silent film you see.

On page 78 there is a discussion of drum developing. This method also does not produce truly uniform developing. The most common defect of this technique is what is called “Bromide drag” which is evidenced by a low-density smearing effect following dense objects. Bromide is a byproduct of developing which, if not quickly dispersed in processing, retards development of the image. The effect is most commonly seen in positive images but can happen in negative development if agitation is not sufficient. The screen effect will then be the opposite of what I described above for positives.

Page 79 describes several things which are still employed in black-and-white processing today, to wit: silver recovery from fixers. Mr. Talbot suggests that the major point of this is to recover silver, but in fact just as important or more so is that the removal of dissolved silver salts lengthens the life of the fixing solution substantially and promotes consistent and rapid fixing of the image.

It is interesting to note that the developing agents suggested are for the most part still in common use. This is also true for the fixer, though in this text sodium thiosulphate is referred to as hyposulphite of soda! Talbot’s remarks on drying conditions are still true and practiced much more rigorously then in Talbot’s day.

Attention should by paid to page 80’s comments regarding different developing conditions for different sections of film depending on what the exposures were in a given day or location. Though this is not so widely practiced today, “pushing or pulling” a negative in processing is still with us if needed.

In the next-to-last paragraph on page 80, mention is made of the lab perforating the film used for positive prints. While this is uncommon today, the practice is occasionally employed to produce certain stocks which are no longer directly available from the manufacturer.

From the bottom of page 80 to the top of page 85 two relatively thorough examinations of printers are described. Each of these printers fall into the category of “Step Printers;” that is, each frame is sequentially stepped through the printer and individually exposed. While this type of printer is still in use today for highly specialized purposes, it is not common today for either the manufacture of release prints or for intermediate films formerly used as duplicate negatives or fine-grain positives, whether in black-and-white or color.

The Newman-Sinclair printer described on page 81 is quaint in its omission of takeup equipment; the film is dumped into a box as it exits the printing aperture! Otherwise, though primitive, the machine exhibits most of the features found on a typical step printer today with one major exception: there is no provision for cueing or changing exposures shot-to-shot! This is a “one-light” printer in its purest form.

A Williamson printer is described beginning on page 82. This machine is considerably more sophisticated than the Newman-Sinclair and does provide a takeup apparatus as well as a rugged and well thought-out approach to machine construction and darkroom use. Means are provided for shot-to-shot exposure changes as well, though they are quite different from today's way of doing things! In fact, one of the devices employed to change the amount of light employed is resistance dimming which cannot provide an instantaneous change of light. Thus one of the giveaways of this is a "sliding" from one light value to another, i. e. a fading-up or a fading-down from one shot to the next. Watch for this when viewing prints from this period.

Once again the concept of a skilled developing operator is emphasized on page 85 using various agitation techniques during the development of positive prints. While this concept flourished until the late 1920's, the introduction of talking pictures brought an end to it. Soundtracks required that prints be developed at a uniform speed and in a totally predictable fashion. Essentially this locked the development of positives to a single desired gamma rather than a multiplicity of gammas as was the case previously.

Also on page 85 a brief mention is made of portable processing outfits appropriate to develop motion picture film in the wild. A more "modern" version of this was the "Morris Tank" widely used during World War II for reconnaissance, gun-sight aiming point films and other purposes.

Finally, a brief and strangely informed observation is made of the processes of fiction film production as well as a recommendation to the home movie enthusiast to send his developing and printing out to professionals rather than to attempt to do this work himself! My response to this admonition: "No guts, no glory!"

CHAPTER VIII

DEVELOPING AND PRINTING THE PICTURES

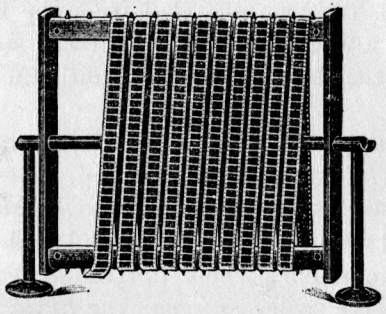
THE history of the cinematograph impresses upon us at every turn the necessity which experimenters were under of devising special facilities and improved apparatus in all of the numerous fields that impinged upon their work. They were obliged to break ground in every direction. For instance, besides securing the right kind of film, they had also to find the best means of developing it. A thin, narrow ribbon of pictures 40 feet in length is a vastly different thing to handle from a rigid glass plate. Its flexibility presented many perplexing obstacles which had to be overcome. Those who used the old roll film with the snapshot hand-camera of the early days, can relate pathetic and humorous stories of the trials and tribulations they suffered in passing the awkward length of film through the developing and other baths. When it was unwound from the roller preparatory to immersion in the developing solution, it persisted in buckling and twisting into strange contortions. Development was carried out in an uneven or patchwork manner, some parts of the film being fully developed before others had betrayed the slightest sign of yielding the latent image.

The plight of the animated photographer was even more unenviable; the handling of sensitised celluloid about as thick as a substantial wooden shaving, was infinitely more exasperating than that used in the ordinary hand camera, for the latter was wider, thicker, and far shorter.

The developing methods at first advocated were of the crudest nature possible. Messrs. Lumière tried to assist

the tyro by comprehensive explanation of a very simple way to carry out the task. They suggested suspending the coil of exposed film upon a rod slipped through the centre of the bobbin to form a kind of spindle, upon which the coiled film was free to revolve over the bath. The operator was then told to unwind the coil very rapidly by hand, passing it into the bath between the fingers, which acted as a guide.

It appeared an absurdly simple operation, but without considerable practice it defied success. One had to be extremely careful not to damage the delicate sensitised emulsion of the film while uncoiling it; that no greasy



By courtesy of Messrs. Butcher & Sons, Ltd.

FIG. 7.—HOW THE FILM IS WOUND UPON THE WOODEN FRAME FOR DEVELOPING.

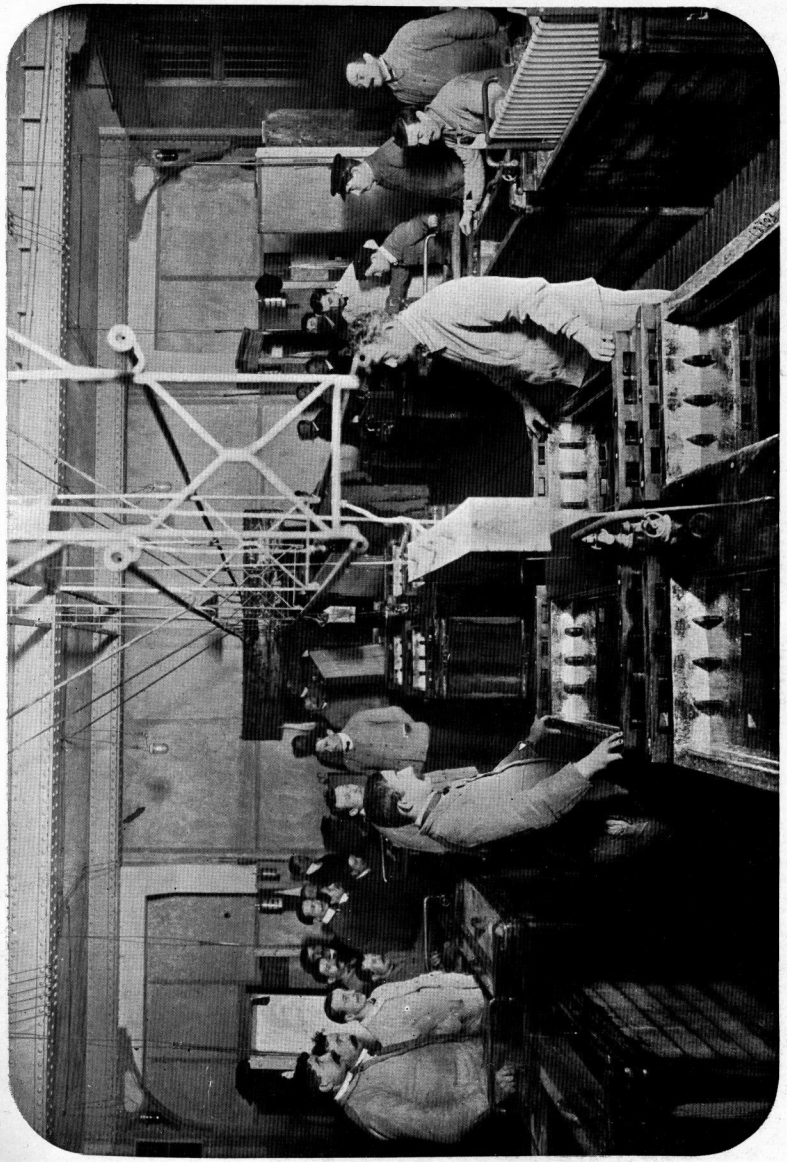
matter, such as perspiration from the fingers, might come into contact with the gelatine surface; and no bubbles must be produced while feeding the slippery strip into the bath. Mr. Robert Paul experienced these troubles, and displayed considerable ingenuity in the evolution of special means to avoid them. The efficiency of his method is proven by the fact that in the main it is practised to this day.

His solution of the problem was simple, safe, and satisfactory from every point of view. He took a light, square wooden frame, similar to that in Fig. 7, which rested loosely upon two uprights in such a way that it could revolve. The free end of the film was fixed to one side of the frame, and the film was then passed from one side to

the other, as if being wound upon a wheel, as it was uncoiled from the spool, the inner end of the film being likewise secured to the frame. This rack was dipped first into a vertical tank to soak the film, and then was placed in a flat tank or trough to be developed in the same way as an ordinary glass plate. By this means every part of the exposed surface was developed equally. Development carried to the requisite degree, the frame was withdrawn, washed, and finally immersed in the fixing tank, which was of the same horizontal design. When the image was fixed it was placed in another tank and received a thorough washing, to remove all traces of the fixing solution, as in the ordinary developing process. This task completed, the film was uncoiled from the flat rack to be re-coiled upon a wooden drum, which was suspended from the ceiling in the drying chamber, until the film was dry and hard.

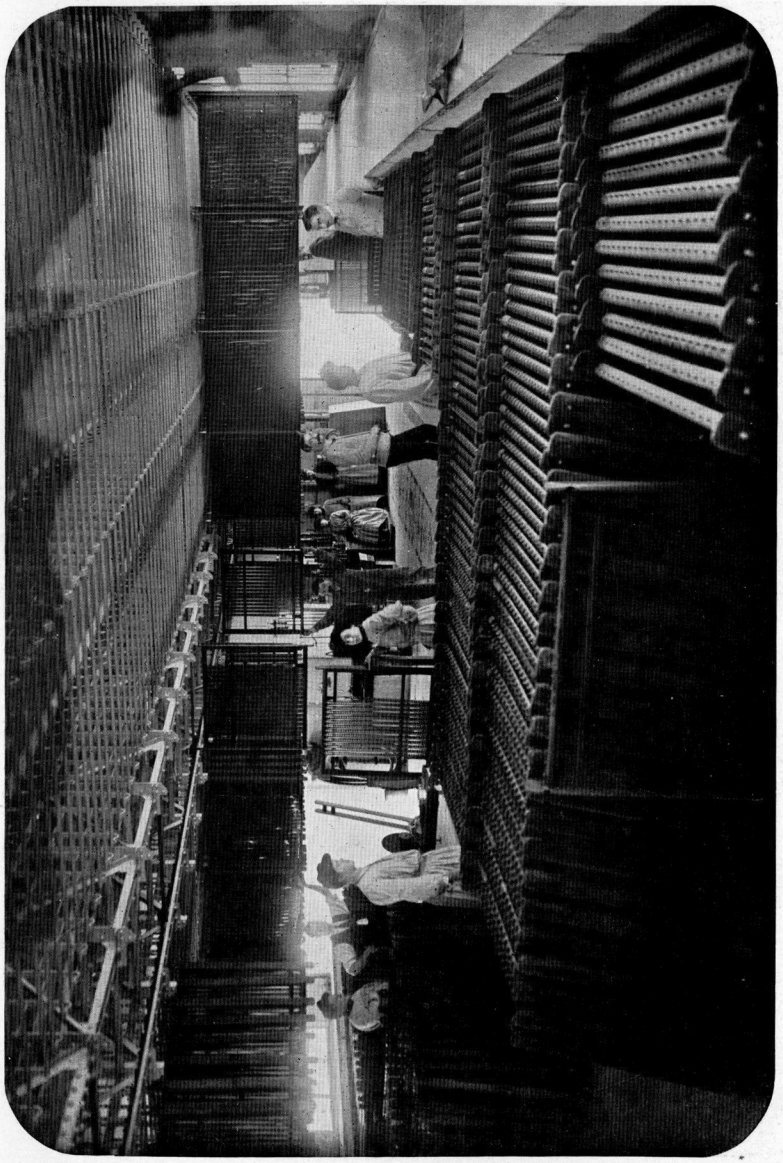
As may be supposed, different factories practise different methods of carrying out this operation. Nowadays a film may be as much as 300 or 400 feet in length, and consequently special methods have to be employed. I have been in some establishments where development is carried out upon an extensive scale, in which the films, as withdrawn from the camera film box, are wound at once upon a large wooden reel, seven feet or so in length, suspended upon brackets above the developing bath. When the drum has received its full length of film it is lowered into a deep tank containing the desired solution, and there kept revolving slowly and steadily until the treatment has been completed. Then the reel is withdrawn by two men and lowered into the next bath; and so on until at last the reel finds its way into the drying room, where the film is uncoiled from the developing drum and re-wound upon the drying reel. The disadvantage of this process is that two men are required to handle the reel, whereas, when a frame is used, one pair of hands is sufficient.

The developing and printing rooms in a large film-picture factory are highly interesting hives of activity. Large troughs and tanks containing the various solutions



THE DEVELOPING ROOM AT THE PATHÉ WORKS.

The films are wound upon wooden frames and immersed in large tanks containing the various solutions.



THE DRYING ROOM AT THE PATHÉ WORKS.

This illustration shows the wooden frames upon which the lengths of film are wound and the overhead racks from which they are suspended.

are on every hand, together with adequate supplies of running water. Everything, of course, is carried out in semi-darkness, the only light available being that emitted from ruby lamps. The fixing solution after it has served its purpose is not thrown away, but is subjected to a chemical treatment to recover the bromide of silver which the hyposulphite of soda has dissolved from the sensitised emulsion on the film. The silver in suspension is precipitated by chemical action in a thick sediment. In large works this recovery process is profitable, several pounds of this metallic silver being secured every week.

The solution employed for development is either a combination of hydroquinone and metol, or a bath of rodinal, developing agents which are familiar to the amateur photographer, while the fixing bath is a solution of hyposulphite of soda. The developing formula is modified by various firms as a result of individual investigation. The drying operation is one that has to be carried out very carefully; the temperature of the chamber must be evenly maintained, and the air which is circulated through the room must be filtered before admission, in order to arrest all particles of dust which otherwise might settle upon the gelatine surface and wreak appreciable damage.

In the early days the fickle character of the film was a serious difficulty. If it were dried too rapidly it evinced a tendency to curl, and severe shrinkage often ensued. To guard against this trouble the film was glycerined before being dried, by being passed through a bath containing a solution of glycerine and alcohol. The improvements effected in the manufacture of the film, however, have enabled this subsidiary treatment to be dispensed with. In cases where a topical film must be rushed out quickly to catch the public in the height of its interest, however, drying is accelerated by subjecting the film to a bath of alcohol in some form or other.

Although a spool of film, measuring perhaps 300 feet in length, is handed over for development, possibly that 300 feet carries two, four, or more exposures, *i.e.*, different sections were exposed at different times, on different days,

or under different conditions of light, &c. The camera operator has indicated the end of each exposure by means of the camera punch. When the developing operator receives the spool, he first searches for such marks as he uncoils the film, and the latter is severed at those points, and each exposure is developed separately. When the developing process is completed, therefore, the film relating to one subject is in a fragmentary condition. These odds and ends have to be sorted out, all useless parts cut away, and then arranged in sequence and joined together to form a continuous band containing, in the ordinary case, the whole subject. If the series of pictures runs into two or three thousand feet, the aggregate will be divided into 1,000 feet sections, which is the approximate capacity of the spool mounted on the projector. The sections are united by means of a transparent cement, known as amyl-acetate.

When the negative is dry and the gelatine surface has hardened enough to permit the sections to be handled and joined together, the next stage is taken in hand. This is printing the positive. Obviously a printing frame, such as the amateur uses for printing from a single glass plate, is quite out of the question with a negative several hundred feet in length. Invention born of necessity has met this question in a novel manner, and the printing process is one of the most interesting phases in the preparation of a picture. Considerable mechanical ingenuity has been displayed, and various types of printing machines produced; but for the purposes of explaining the subject most lucidly and comprehensively two typical machines will suffice. Before printing, however, the raw film or stock intended for the purposes of the positive or transparency must be perforated, an operation which is similar to that followed in perforating the negative film.

Printing is carried out by contact; that is to say, the sensitised surface of the positive film is pressed tightly against the emulsion side of the negative film at the instant the exposure is made. One image is printed at one time. The two films are given an intermittent action, the consecutive images on the negative film and the corresponding sections of sensitised surfaces on the positive film being brought before the illuminant during the brief period that the light is cut off from the printing box by the passage of the shutter.

In the Newman-Sinclair apparatus, Fig. 8, the negative-film is wound upon spool 1, while the positive film is carried on spool 2, both being supported upon the projecting bracket 3. The negative passes over the guide roller

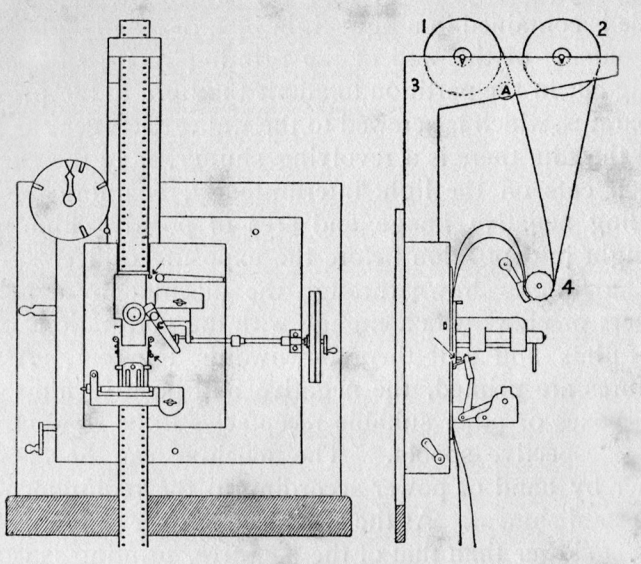


FIG. 8—FRONT AND SIDE VIEWS OF NEWMAN-SINCLAIR PRINTING APPARATUS.

A, and descends with the positive film to the toothed sprocket 4. At this point the two films are brought together with the gelatine surfaces inside, while the teeth of the sprocket mesh with the perforations in each. The two films pass from this sprocket, form a loop, and together enter the gate, which clamps them tightly and flatly together, with their respective perforations exactly coinciding.

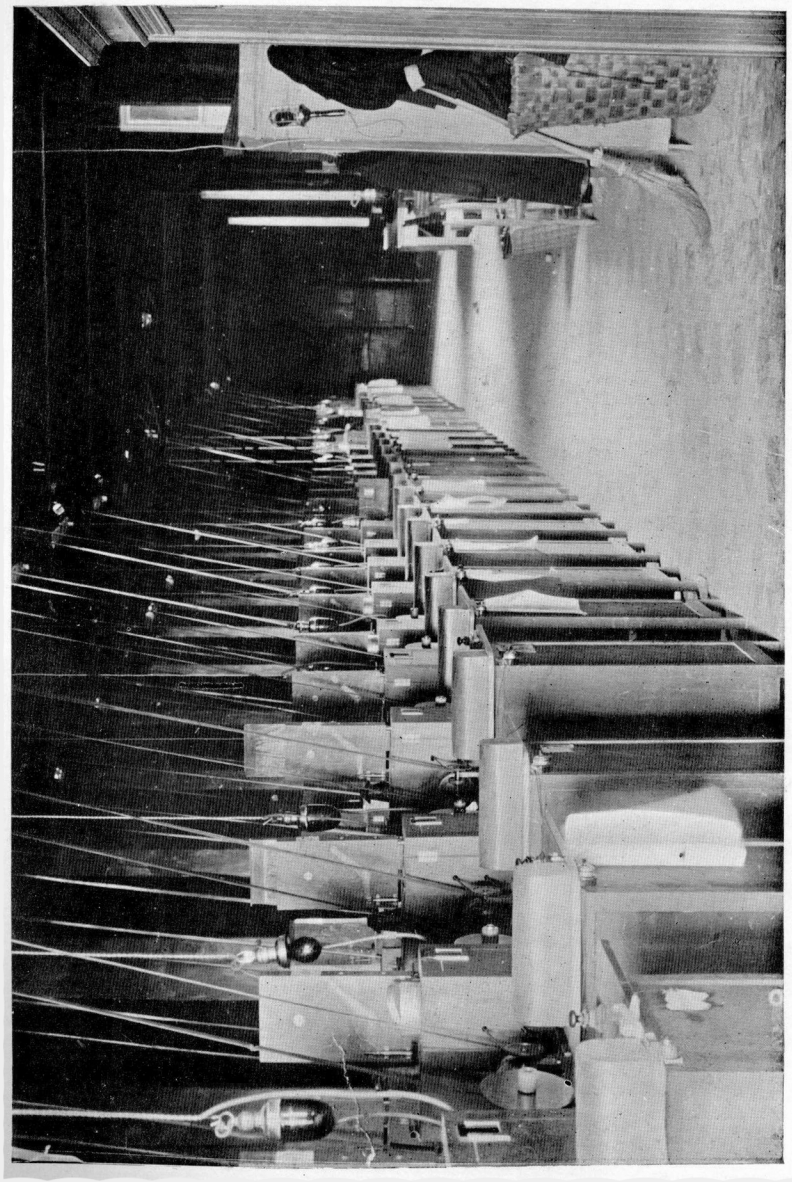
At the point where the two films come opposite the aperture through which passes the light from the lamp, there is a mask, by which the position of the picture relative

to the exposure hole is corrected. The mask also determines the shape of the positive picture. It may be rectangular, oval, circular, or have rounded corners as desired. Immediately behind the film, in line with the exposing aperture, is a red screen, over which a shutter slides. When this shutter is opened, the operator can see the negative image through the positive film, and thus can ascertain that the position of the picture is correct in relation to the exposure aperture, and also that the perforations on the two films are in synchrony. The light by which the exposure is made is contained in a light-tight box, or may be placed on the outside of the wall of the printing room, an aperture being cut in the partition to admit the light to the printing apparatus, which is screwed to the wall. Between the light and the film there is a revolving shutter, as in the camera, which cuts off the light intermittently, enabling the succeeding negative image and area of positive film to be brought into position before the exposure orifice.

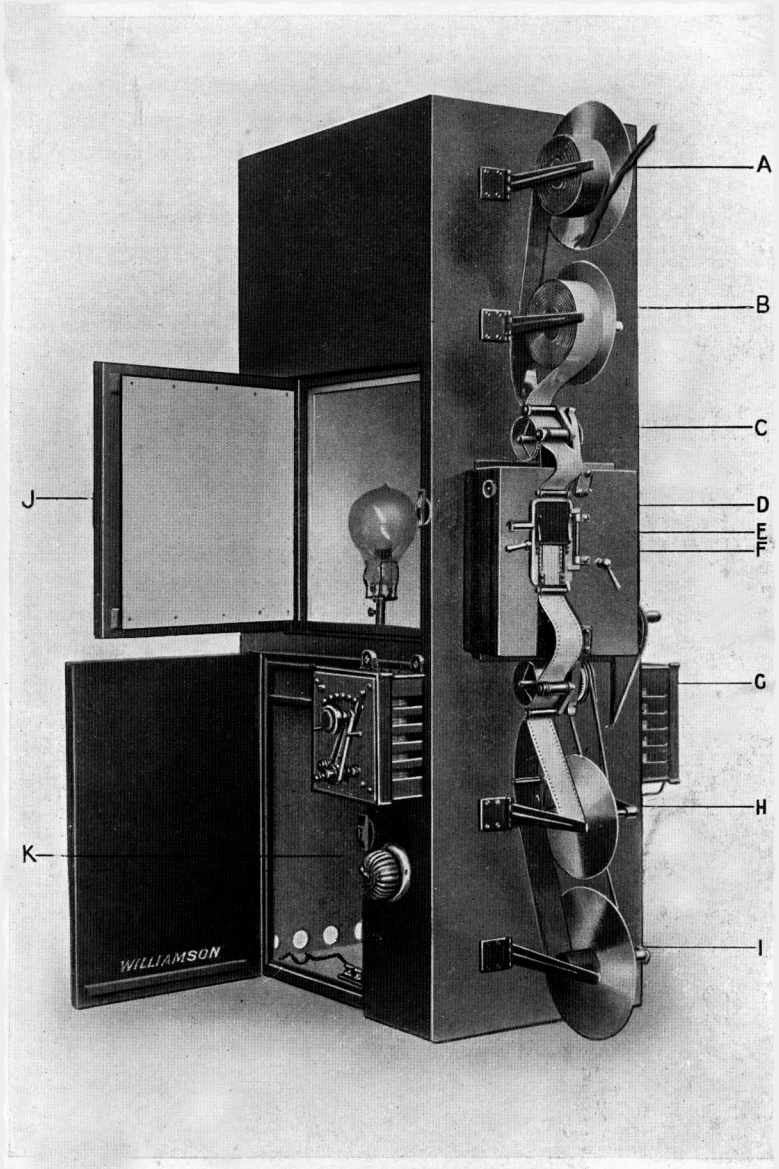
The film is drawn through the machine by a pair of fingers or claws which engage with the perforations of the two films and pull them downwards together. As the pictures are printed, the negative and positive films pass into boxes or other suitable receptacles to be re-wound on their respective spools. The machine can be operated either by hand or power according to the requirements of the establishment. As the sensitised surface of the positive film is slower than that of the negative, printing is carried out at a reduced speed, the average recommended with this apparatus being about five pictures per second.

Another printing machine has been recently produced which is regarded as the simplest, most mechanically perfect, most compact, and self-contained apparatus yet devised for this work, and which compels attention as much from its efficiency as from the point of view of mechanical excellence. This is the Williamson printer. It is a complete unit, and can be moved from place to place with facility.

It comprises a large rectangular box or cabinet, standing on one end. The front face carries the printing mechanism,



A ROW OF PRINTING MACHINES IN THE ROME WORKS OF THE CINES COMPANY.
This establishment is able to print 100,000 feet of film per day.



THE WILLIAMSON PRINTING MACHINE.

For making the positive films.—*For explanation see page* 82.

while the interior, divided into two compartments, contains the driving mechanism and the illuminating agency for printing. The apparatus is so designed that after printing the films are wound upon separate spools at once, thus saving time, and dispensing with the necessity of a box or basket to gather the loose films, which is both a dangerous and an unsatisfactory process, inasmuch as the films are liable to become damaged by curling and cracking, and through the surfaces rubbing against one another.

The negative film is placed upon the spool *A* immediately below which is the positive film spool *B*. The sensitised surfaces of the two films face one another, and the two are brought together as they pass under the grip rollers and over the toothed sprocket *C*, where the teeth mesh with the perforations in the respective films. Issuing from this sprocket a loop is formed, and then the films enter the gate *D* over the printing aperture. This gate is side-hinged, and when closed it presses evenly upon the whole surface of the films under exposure, ensuring a perfect even contact. There is a small red screen *E*, which, when released by means of a small lever, drops down, thus enabling the negative to be examined without danger of the positive film being fogged in the operation. By this means the printer can satisfy himself that the picture is central to the exposure hole.

As the picture is printed, a simple claw device *F*, resembling two hooked fingers, engages with the perforations in the two films and draws them downwards. This claw device is of very simple construction, working on a cam, so that when the film has moved downwards the proper distance—sufficient to bring the succeeding picture and its area of unexposed positive film before the printing aperture—the fingers disengage themselves from the films, rise, and move upwards to drop into other perforations and repeat the operation.

As the film descends, it forms a loop, and passes under a double smooth-faced roller and a toothed sprocket *G*, at which point the two films part company, the positive to be wound upon the bobbin *H*, while the negative film is

wound upon the lower bobbin *I*. These lower spools are driven by belt and pulleys from a bevel gear wheel, which carries a spindle actuating the claw giving the intermittent movement to the films, and which by means of another spindle rotates the upper and lower sprockets *C* and *G* so that the loops above and below the gate remain constant. By this arrangement no pull or strain is imposed upon the films by the sprockets, which act merely as guides and not tractive devices.

The compartment *J* is lined with asbestos, and contains the illuminant by means of which the printing is done. An electric lamp of 50 candle-power, having a filament in the form of a grid, is placed directly opposite the window through which the exposures are made. This lamp is mounted upon a slide controlled by a lever on a quadrant on the face of the machine, by means of which it may be moved as required from 2 inches to 10 inches from the printing window. The power of the light may be varied according to the density of the negative by means of a controller, which increases or decreases its intensity in much the same way as a gas jet can be turned up or down, it being possible to secure six variations in light intensity ranging between 16 and 50 candle-power. When the door of the chamber is closed the compartment is perfectly light-tight, though ample ventilation is secured.

The lower compartment *K* carries the electric motor by means of which the apparatus is driven, and the speed of printing is altered at will by means of a controller. The motor is of 1/12 horse-power, and six direct speeds can be obtained. The drive is communicated to the mechanism through a system of cone pulleys, which enable three speeds to be obtained; and as each of these three speeds can be given one of the six speeds of the motor by means of the regulating switch or controller, the apparatus can be driven at eighteen different speeds, according to requirements. Wide range of action, combined with simplicity of control, characterise this apparatus. The printing speed varies according to the density of negative and the intensity of the light, but the average speed in printing from a

normal negative is about 500 exposures of pictures per minute.

The positive film, after being exposed, is developed by a method similar to that used for the negative. Both these developing processes demand considerable skill and experience in order to ensure the best possible results. An accomplished developer, like his colleague working with glass plates, can rectify many deficiencies arising during exposure. The camera operator often has to work under the most adverse conditions concerning light, and it is the task of the man in the dark room to obtain the utmost from a poor negative. By care and attention, combined with experience and knowledge, he will be able to improve, make up for under-exposure, and mitigate the evils due to over-exposure. It will be realised that development is the most critical stage in the whole operation, for upon the manner in which it is carried out much of the excellence and merit of the projected picture depends.

The fact that the cinematograph camera is being regarded more and more as an indispensable unit in the impedimenta for travelling and exploring expeditions has resulted in attention being devoted to the perfection of a small portable developing outfit to enable films to be developed at once, instead of sending them home for treatment, as hitherto has been the case. The "N.S." developing apparatus is an excellent appliance of this character. It has been taken by Captain Scott, R.N., upon his Antarctic expedition, and forms part of the photographic outfit carried by Mr. Cherry Kearton upon his travels. The developing apparatus consists of a rotating cylinder and two or more semi-circular troughs. The film is wound spirally upon the drum, being held in position by means of wire staples, and the apparatus is so designed that the drum with its film can be moved from one trough to the other by the simple movement of a lever. The design of the apparatus ensures economy in the quantity of developer required. Three pints of solution are sufficient to treat 75 feet of film, and the bath can be thrown away when work is finished or bottled for further use.

After washing, the film is wound upon a collapsible drum, which folds into a small space when not in use. The outfit is made of pine, with waterproofed joints, the whole of the woodwork being treated with paraffin wax to render it impervious to the action of chemicals and moisture. When packed, the apparatus, capable of dealing with 50 feet of film, measures 3½ feet in length, by 26 inches wide, and 18 inches deep. The outer packing constitutes the support for the apparatus when in operation.

Waste is absolutely unavoidable in the cinematograph industry, and no matter how carefully operations may be conducted, it is bound to assume impressive proportions. In a travelling expedition the operator records pictures of what he deems to be sufficiently interesting from various points of view—scenic, ethnographic, historical, or merely anecdotal and humorous. When the films are developed and a trial positive is struck for projection before the powers that be, to receive official approbation and sanction to enter the market, the critics in the private projecting room sometimes fail to see eye to eye with the cinematographer, and deem this and that to be lacking in the essentials which render a film attractive to the public. Accordingly, these sections are eliminated. From 300 to 3,000 feet may be destroyed in this manner.

The waste is still greater in the filming of picture plays. Sometimes a scene, occupying 100 or 150 feet of film, will have to be photographed three or four times. I once saw a scene, taking 200 feet of film, recorded six times before it gave satisfaction. It was a picture involving the movements of a large crowd, and in five instances something went wrong at one point or another, despite the fact that rehearsals had been prosecuted with such energy and persistence that at last everything appeared to move with the precision of the wheels of a watch. A thousand feet of film were spoiled in this particular case, which, at an average of 1½*d.* (three cents) a foot, represented a waste of £6 or $30 in film alone. Yet this is by no means an isolated instance; the proportion often approximates 20 per cent.; that is to say, 200 feet out of 1,000 feet are useless.

The bigger the production being recorded, the heavier the waste in this direction.

When the positives have been dried and hardened sufficiently to enable them to be handled, they are sent to a room where the different sections are identified and allotted to their positions in the subjects to which they belong. The sections are joined together, the lengths of film bearing the explanatory sub-titles are inserted in the proper places, and the whole subject, after a final examination, is wound upon a spool ready for the market. The examination of the films is carried out rigorously, those suffering from the slightest blemish or coming below the firm's standard being discarded.

It has been seen from the foregoing that the preparations for developing and printing are somewhat elaborate, and demand expensive apparatus in order to insure the most satisfactory results. These considerations react against the amateur cinematographer. But should one fall a victim to the fascinating glamour of cinematography, one need not apprehend difficulties in connection with developing and printing. There is no necessity to acquire perforators, to establish a complete developing room, or to invest in a printing machine. The majority of cinematograph manufacturing establishments undertake to develop negatives, and to supply positive prints ready for projection at a nominal figure. It is far better to entrust the work to a skilled staff, who can be trusted to handle the film successfully, than to attempt to wrestle with unknown difficulties with a serpent-like film 200 feet long, in the murky gloom of the dark room.