Film-Tech

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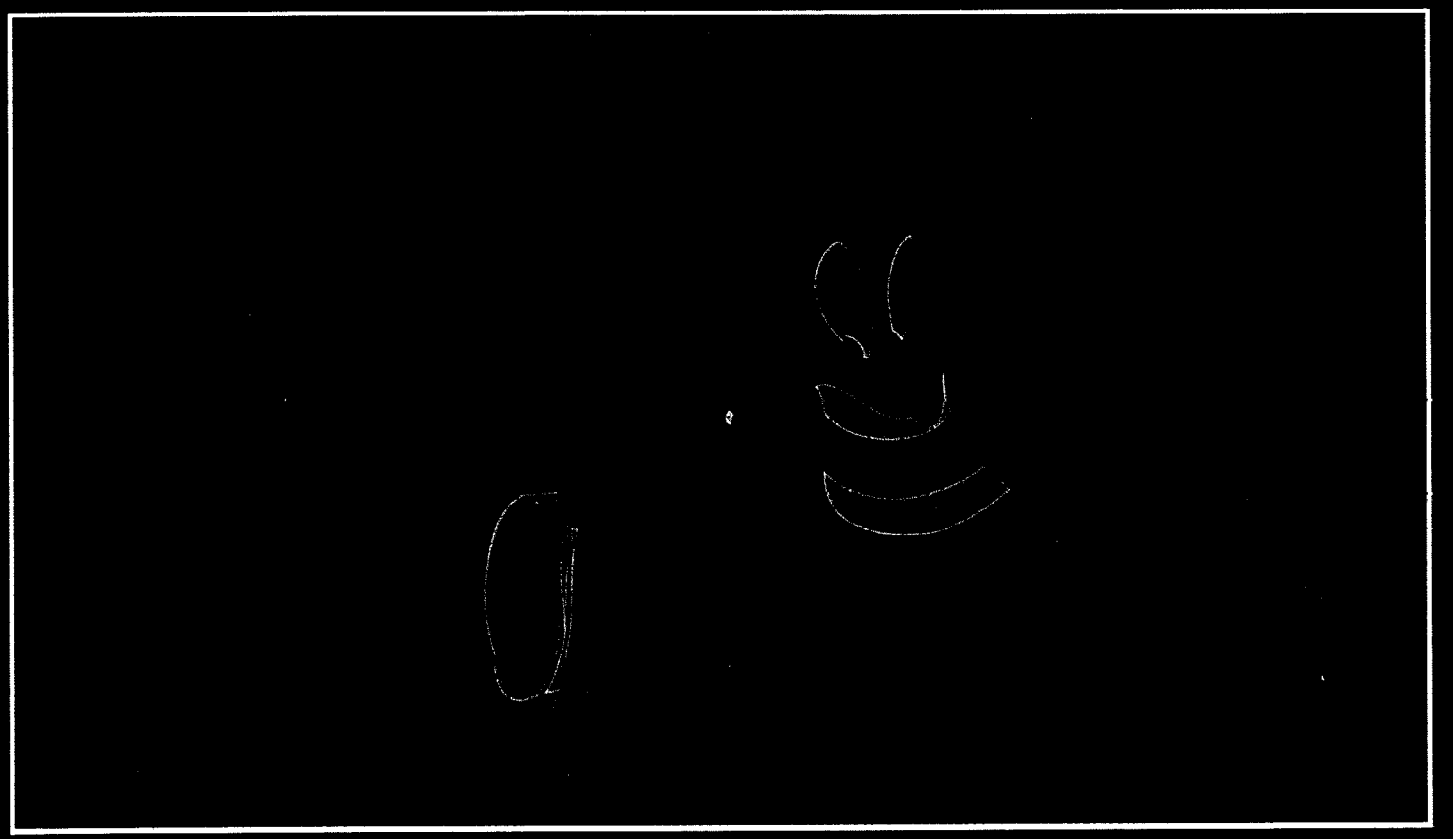
FILM NOTES FOR THE

REEL PEOPLE

H-50-30

A TECHNICAL SERVICE FOR FILMHANDLERS FROM EASTMAN KODAK COMPANY



Through the Looking Glass: The Magic of the Projection Lens

FILM NOTES FOR THE REEL PEOPLE

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A TECHNICAL SERVICE FOR FILMHANDLERS FROM EASTMAN KODAK COMPANY

WINTER 1992

Letters to the Editor

Dear Film Notes,

Frequently, our theatre receives trailers that seem to be on a thinner stock than the feature itself. Is there a reason for this? Do these trailers need special attention?

George Sandford, Miami

In the United States, most features are printed on print stock that has a cellulose acetate base. Sometimes you will see trailers that are printed on polyester base film which is about 15% thinner and feels a bit stiffer than acetate.

We would advise you to tend to the following areas when threading and handling this polyester stock:

1. *Because polyester is very sturdy and resistant to tearing, it can actually "choke" the platter "brain" upon start-up if a brain-wrap or tail-wrap should occur due to improper take-up platter speed variations. Monitor your start up more closely when using polyester.*
2. *Only non-oozing, pressure-sensitive splicing tape may be used when splicing polyester to acetate. Hot splices or cement splices will not hold the edges together during performance.*
3. *Heat energy generated from the lamphouse can cause the emulsion to expand during projection. This affects focus. Since polyester and acetate are of different thicknesses, it may be necessary to make a focus adjustment, particularly on very large screens, between polyester trailers and acetate features. Make sure an operator is standing by to make this adjustment, should it be necessary.*

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If you have any questions or comments, please write to:
Editor, *Film Notes for the Reel People*,
6700 Santa Monica Boulevard,
Hollywood, CA 90038.

Interview

Aladdin Directors' Dream of Genie

You may not readily associate the names of **John Musker** and **Ron Clements** with children's hopes, dreams, and aspirations, but you should. In the realm of animation, these two very humble and inspirational men are carving out a legacy that will last for generations to come. For over 50 years, most of the world has grown up with Walt Disney's classic animated films—*Snow White, Pinocchio,* and *Fantasia*—to name just a few. Mr. Clements and Mr. Musker are carrying on this legacy. Not only are they responsible for the 1989 smash hit *The Little Mermaid,* which they co-wrote and directed, but they are also the creators of *Aladdin*, another soon to be Disney Classic.

Can you tell us something of your backgrounds?

JM: I started doing cartooning for my high school paper and kept at it through college. Disney rejected a portfolio I sent them, but referred me to Cal Arts' animation program. I took their advice and, ironically, Disney recruited me there when they had come to campus to see student work. That was in 1977 and I have been there ever since. I initially worked on a Christmas short called *The Small One,* then *The Fox and the Hound* and *The Black Cauldron.*

I was a writer and co-director on *The Adventures of The Great Mouse Detective* prior to teaming up with Ron to co-write and direct both *The Little Mermaid* and *Aladdin.*

RC: I've been interested in animation since I was a kid. I came to Los Angeles after graduating from high school and worked at Hanna-Barbera for a short time while taking classes at Art Center. I got into the talent development program at Disney in 1974 and worked as an animator for about 5 years. I moved into story, direction, and so on.

How long have you known each other, and how did you end up as a directing team?

RC: I first met John when he was an intern at the studio and I was an animator. He was still going to Cal Arts, but he came over for about a six week summer period and worked at the studio. We didn't really work together until *The Great Mouse Detective.* We had both done story work on the project, and then were moved into co-directing with Burny Mattinson and Dave Michener. After *The Great Mouse Detective,* I had pitched *The Little Mermaid* as a project and they were really interested. I talked to John about collaborating and writing the script for *Mermaid.* We co-wrote the script and went on to direct it. We seem to work well together, so we went on to *Aladdin.*

What was the first animated movie that you remember seeing as a child?

JM: *Sleeping Beauty* was one of the bigger films of my age. I was six at the time, and it had a big impact. It was released in 1959, and at the same time I had seen *The Art of Animation* book by Bob Thomas in the library, which explained a little bit about how animation was done, and it intrigued me. *Sleeping Beauty, Pinocchio,* and *101 Dalmatians* were really the first big three. These films were the strongest of my childhood and drew me toward animation.

RC: The first animated feature I saw as a kid was *Cinderella,* although I was pretty little at the time. It didn't make a real strong impression. It was *Sleeping Beauty* that made the impression. It wasn't too long after that I saw *Pinocchio,* which was even more impressive. It marked the first time I really wanted to get involved with animation. I drew a lot as a kid, and when I saw these movies, I would buy the books, and draw the characters.

What live action films and directors inspired you as well?

JM: *The Wizard of Oz* was one of the stronger influences I had as a child. As I got older I began to have a great admiration for Alfred Hitchcock, Robert Altman, John Ford, Billy Wilder, Bernardo Bertolucci, Steven Spielberg and John Huston, just to name a few. They are all stylish visionaries, that have a strong visual sense. That's what I responded to. They can tell a story by using the visuals to communicate not just the story, but the ideas underneath. It is a constant education.

What advice would you give to someone that is interested in getting involved with the animation field?

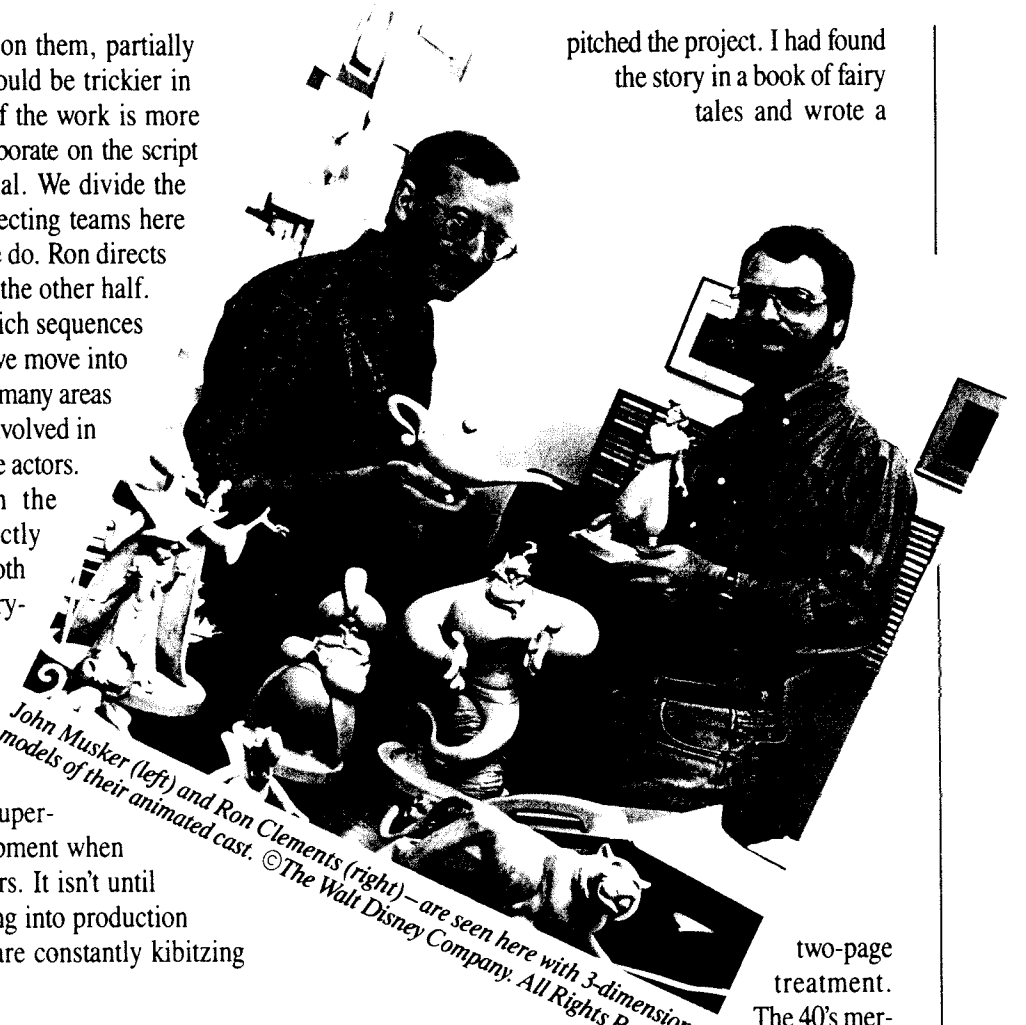
RC: Drawing, of course, is certainly very important. I would recommend a lot of quick sketch and life drawings. Focusing within the animation field is another. There are a lot of different areas, such as animation, story sketch, layout, background painting, etc. They each require different skills. Background painting is more work with color. Animators need to be good at quick sketch and to have a sense of acting and entertainment. It is good to stay focused and work very hard. In terms of a school, I think Cal Arts probably has the best training program right now for learning animation in a way that will enable one to find work within the industry.

Living in Los Angeles or New York is helpful – especially Los Angeles – because of the film industry.

The co-director phenomenon is fairly uncommon in live-action. Is it more prevalent in animation?

JM: It does seem to happen more in animation because of the workload involved. *Snow White, Pinocchio,* and most of the great Disney features had

at least three directors working on them, partially because of all the minutia. It would be trickier in live-action because the nature of the work is more difficult to split. Ron and I collaborate on the script and re-write each other's material. We divide the film into sequences. Not all directing teams here at Disney approach it the way we do. Ron directs Half the sequences, and I direct the other half. We negotiate who's directing which sequences as we develop the script. Then we move into production. We work together on many areas to maintain unity. We are both involved in all of the recording sessions of the actors. Ron is usually out there on the recording stage working directly with the actors, and I'm in the booth hearing it slightly removed and trying to provide the animator's ear. We'll be hearing it on tape later without the benefit of actually seeing the actors perform We both pick the best voice takes. We both work with the supervising animators during development when they are setting up the characters. It isn't until the sequences really start moving into production that we split up the work. We are constantly kibitzing throughout production.



John Musker (left) and Ron Clements (right)—are seen here with 3-dimensional models of their animated cast. ©The Walt Disney Company. All Rights Reserved.

With the script, Ron is more structure oriented. He has a really good story sense. I am slightly more detail oriented in specific dialog, business and gags as well as other areas. In the film we break it down. I have worked on the action-adventure sequences, and Ron has done some of the tender, character-oriented moments. It doesn't exclusively fall that way, we try to mix it up. Through the course of production, we constantly review each other's work and make suggestions. It's good to have someone who can look at ideas and problems with a little fresher eye. In terms of layout, background and color work, we really work pretty collaboratively on that. We both review all the color models of the characters and the backgrounds and that sort of thing so that we are on the same wavelength.

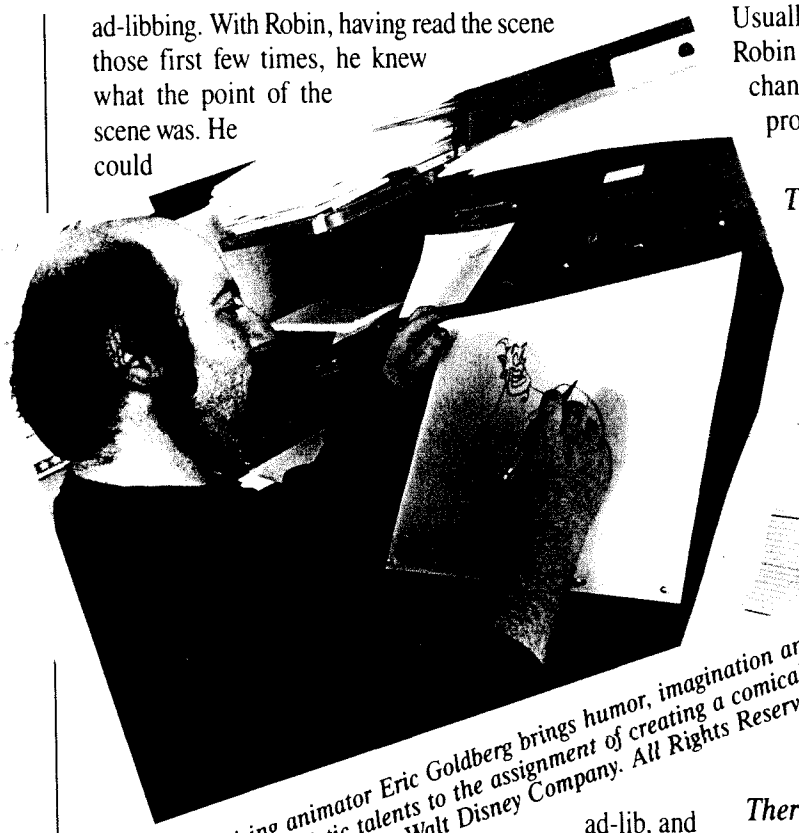
Didn't* The Little Mermaid *start off as a Disney project back in the 40's?

RC: Yes, there was work done on a mermaid project in the 1940's. I didn't know about it when I pitched the project. I had found the story in a book of fairy tales and wrote a two-page treatment. The 40's mermaid material was to be used as part of a Hans Christian Andersen compilation project. We went into the archives and found some of the original visual materials. They had done some conceptual work on a shipwreck sequence involving a big storm. They were just drawings, but we used them as an inspiration in the movie.

What was it like to work with Robin Williams? Did you just let him go and animate around his dialog?

JM: We wrote the script with Robin Williams in mind. We thought that his peculiar approach would really work well for the character. So we wrote it "Robinized," which is to say, we did a lot of zipping around in terms of his approach, switching from one persona to another. We weren't as extreme as the film wound up, which was driven in part by Robin's improvisations on the stage. What we did was record the script as written a number of times. We would encourage Robin to improvise and he would start

ad-libbing. With Robin, having read the scene those first few times, he knew what the point of the scene was. He could ad-lib, and yet understand what the story point was. He brought things to the scene that were completely out in left field and yet helped support the story. Or if he went off on complete tangents, he would bring it back around. For example, in his introduction as the Genie, he did literally 25 complete takes. Of those, the first 8 or so were relatively what was scripted. After that, each take got a little further away. In the beginning we had a scene that was a minute and a half end up being 10 minutes long after Robin had worked it up. He just embroidered it, and tried different things. We would kick in ideas, tell him what we liked, and have him try different spins. Eric Goldberg, who was the directing animator for the Genie was there at the sessions. He might make suggestions to Robin on certain line readings. What we used for the film was from many different takes. We had a *ton* of tape! Ron, Eric and I would sit in a room, after all of Robin's takes had been transcribed, and find the funniest stuff. We reviewed the tapes and tried to boil it down to a "Best of Robin" version. Then we had to say "OK, now how do we rebuild the scene, which lines can we use to still support the story point." Sometimes we would have to whittle it down further, and go through another step to rework the storyboards that had previously been done.



Supervising animator Eric Goldberg brings humor, imagination and his impressive artistic talents to the assignment of creating a comical Genie character. cast. ©The Walt Disney Company. All Rights Reserved.

Usually the storyboards are based on the script. So if Robin improvised something, it might necessitate a change in the storyboards. I can't really say what proportion of Robin's material was improvised.

This process alone sounds like an amazing collaboration between actors, directors and animators.

JM: It has to be. I have to say, that Robin was very hard-working and completely open to any suggestions. He also had a million ideas that he wanted to try. I'm sure that it was very liberating for him, too. Because it is all on tape, he didn't have to worry about visuals when he was recording, so his mind could just run free. He can just click into that higher gear. . .I couldn't figure out how his mind could work that quickly, but it can. It really was a sight to behold.

There are many people who have questions about the use of computer animation. How much is actually used? I know that it seems to be increasing. What has it added to the animation experience and how are cels created, painted, filmed, etc.?

RC: We are using computers more and more today. The character animation is still done by hand the way it has always been done. Animators do pencil drawings sitting at drawing tables. We're using computers more for coloring. The traditional cels are not used in the animation process now. The animator's drawings are digitized by the computer and then painted in the computer. They are combined with painted backgrounds which are still painted by hand. The animation is put together in the computer and laser-printed to film. That enables us to do a lot of things that we couldn't do in the traditional cel method. We use computers when we want to do a live-action type camera shot. We can create an environment and move the camera within it in the computer. It's fairly expensive so we don't do that too often. For special scenes, like the ballroom sequence in *Beauty and the Beast*, they could move the camera within the ballroom and do some very elaborate camera shots. In *Aladdin*, it is used primarily for a roller coaster ride through the Cave of Wonders with Aladdin on his flying carpet. We built this tunnel in

the computer that Aladdin is flying through so that we could do some dramatic staging. The magic carpet is really a unique character, the first of its kind, that combined the two types of animation. The carpet was animated by hand, by Randy Cartwright, the same as any other character, except that it's a rectangle. There were a lot of challenges in trying to give it a personality. The pattern of the carpet was done by texture mapping. It was like a piece of wallpaper that we could paste onto the carpet in whatever form it took. That enabled us to accomplish something that could not have been done traditionally. If we had to re-draw that elaborate pattern on the carpet frame by frame for every scene, it would have taken years and years, and it never would have looked as good.

It must be a tremendous feeling to see your creation on the screen, maybe more so than a live action director, who cannot necessarily control an actor in the sense that you can in an animated feature.

RC: It is really satisfying when they turn out right. I mean, there is a lot work, and a lot of people involved. Animated features are not easy to do, and we have done three of them now. But it is nice when its all done. You feel really good about it. I know people are generally aware of how much work goes into an animated feature, but they may not understand that it is an ordeal. It is a huge amount of labor and inspiration and perspiration, and everything else. It's nice when they turn out well, and they have an afterlife. It makes you feel the effort was worthwhile.

In the past 20 to 30 years, animation had been considered fairly dormant, until films like* The Great Mouse Detective, *and* Oliver and Company. *Then* The Little Mermaid *was the film that is considered by most to have brought Disney animation back to greatness. Since then* Beauty *has been a great success, and* Aladdin *is earmarked to be the next colossal hit. Are you having a difficult time finding projects to live up to these standards, or are you swamped?

JM: I don't know. It was daunting for us following *Beauty and the Beast,* which we saw a year ago when it was completed. We saw how involved the audience was and we just shook our heads and said, "How are we ever going to follow this?" On *Aladdin* I think it did goad us to try and not do the same film. It makes us feel we have a standard to live up to. I think it is going to be difficult. I know there are subsequent projects to ours, and they may feel the same way, that it is tough to compete with *Aladdin,* but I think that it is a good thing. I think Jeffrey Katzenberg is on the right track. He is so driven, and will not want the company to have an attitude of complacency. He has the attitude that you have to top yourself, and that if you make a better film, you will be more successful and maintain longer in the marketplace. We do lose our innocence a little with each of these movies. With *Mermaid,* we were just trying to make the best film we could, and it was appealing doing a fairy tale because it hadn't been done for a long time. Now, with *Beauty and the Beast* being so successful, the next project that has a fairy tale theme will really be scrutinized relative to those films. Even our film will be reviewed relative to *Beauty and the Beast* and *The Little Mermaid,* and you would like each film to be judged on its own merits. Hopefully, we won't be doing the same film over and over again, but we will be finding different types of stories to tell and still trying to make them as involving and entertaining as possible. Trying to find fresh hooks and applying all the massive creative talents of the studio is an ongoing challenge.

Could you give us a general idea on how the years in production and pre-production are spent?

RC: *Mermaid* took about four years to make. For *Aladdin* it was a little quicker, not quite three years. The film begins with a specific process in the studio. They start with the idea, then go into development. There may be scripts written, and visual development may occur where drawings are made. Sometimes within development, there are a lot of other projects. Not all of them get made. Others may not get made for a long period of time. It's the exploring stage of a potential project. At a certain time there will be a commitment to say, "Yes, we want to do this; we want to make this film." A director may be assigned to the project, or in the case of *Mermaid,* we generated the project. But in other cases they will assign a director, or usually a directing team (that's what we have at Disney). Once that begins, say with *Aladdin,* that would be about a three year period. Within that three years there was probably a year of script writing, visual development, storyboarding and

casting. We try to get the voices first, than the songs written, before it goes into a production phase involving layouts, animation, background painting, and color. The big production process is about a six month gear-up and then the bulk of that is done within a year. So most of *Aladdin* was animated within a year. We were finished around last June or July. There are still a few months after production when we go into our post production. This involves the sound effects, scoring of the movie, the sound mix, the final dub, and color timing. So, to sum it up, we started with roughly 18 months of development (storyboarding, casting and experimental animation), an intense year of full production (with animation and clean-up) and then another six months of post production.

The music has been such a major factor in the resurgence of the modern Disney Classics. When in the project is the music done or completed?

JM: The music is done throughout production, although in the ideal world, they would like to have all the songs written almost before you go into storyboarding. In the case of *Aladdin*, it was quite complicated because the project had originated a few years ago. Howard Ashman had written a forty-page treatment in prose. He and Alan Menken wrote six songs for it. These were written while we were producing *Mermaid*. After they had completed the songs for *Mermaid*, they were pretty much finished with their part. They were under contract to develop another one, so they developed *Aladdin*. During the development phase writers began creating scripts that got away from some of Howard's songs. Then Ron and I got involved with the project, and we said, "No, we like Howard's songs," even though we had some differences with the story and with some of the characters. We pulled three songs out of the original six. So generally, the songs are demonstrated, or "demoed" for short. When Howard was alive, they did the demos with a simple piano or synthesizer track, and Howard or Alan sang vocals, which sells the songs. We often create storyboards around these songs. On *Mermaid* we recorded the actual production vocals against synthesizer music tracks. The synthesized tracks were later replaced by a full orchestra. On *Beauty* and on *Aladdin*, we went with a little different system. We recorded the vocals and the full orchestra at the same time. That was before any animation was done, so we had those songs completed. With *Aladdin*, we were into production on some areas of the film even while we were recording some of the songs. So it wasn't like they were all done ahead of time. For *Beauty* a lot of the songs were completed earlier. As you do story re-writes, sometimes the songs may change. For example in *Beauty and the Beast*, "Be our Guest" was originally to be sung to Belle's father, Maurice. However, because of various story changes, they felt they wanted to involve Belle more in the story, so they sang it to her. They had to go back and re-record all of these things where they used "he" as well as change all the pronouns. Generally the songs precede the animation, but they may be done while other parts of the movie are in production.

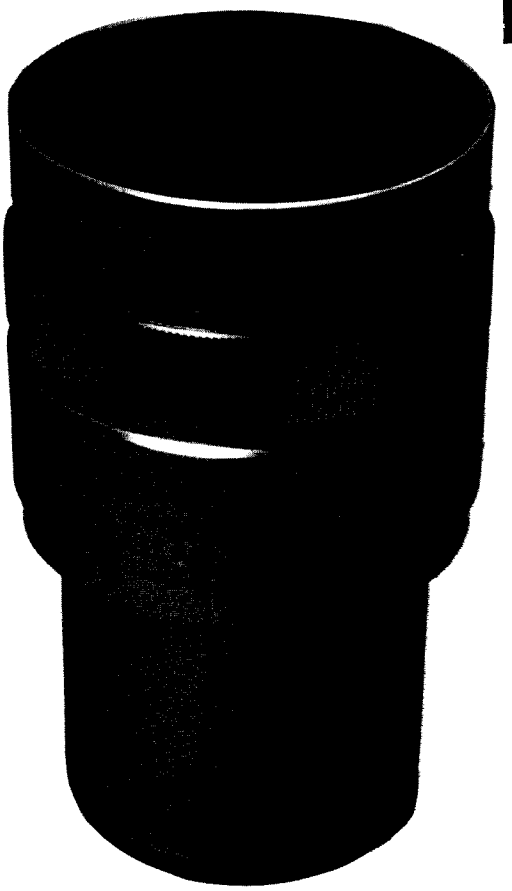
Did you know that **Aladdin** *was the first feature to use Kodak's new 5244 intermediate film stock?*

RC: Yes, we knew about the new film stock, but we didn't know that we were the first to use it. There was a lot of testing done early when we began the project. We had discussed it with Richard Vander Wende, the production designer, and Bill Perkins, the art director. Once we had decided on the basic color palette of the movie, we knew that we were going for a fairly high saturation, a bold look. This was different than *Mermaid* or *Beauty* which had more delicate looks. This new film seemed to address our concerns. The hot colors, the reds and the yellows, needed to be vibrant with heavy saturation. In the past, during the answer print stage it had all looked great, but somewhere in the stage between the answer print and the release print some of the color saturation was lost. This was the main reason we wanted to use the new stock. We are very happy with the way it turned out.

Through the Looking Glass

The Magic of the Cinema Projection Lens Part II

by Glenn Berggren
Projection Consultant



A. *How to Get the Best Images from Projection Lenses—Continued from #H-50-29, Fall 1992*

Projection lenses are designed with several assumptions, which are required to finish the design. To *get the best* from the lens, the assumptions below must be considered in using the lens:

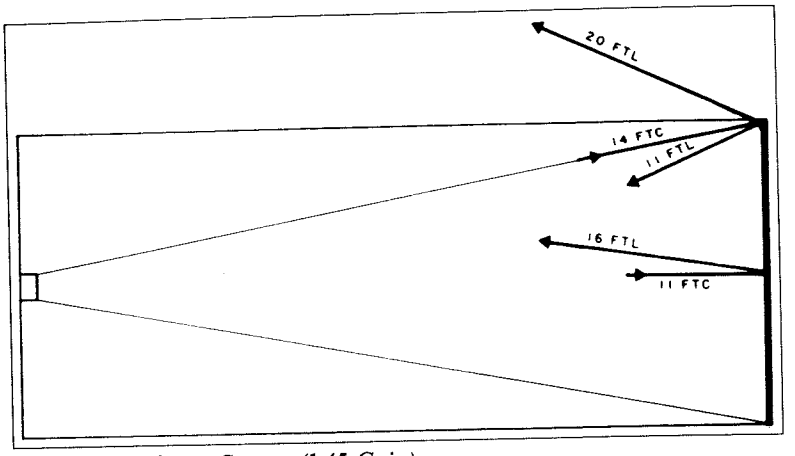
First, with the large aperture, the designer assumes uniform intensities of light entering in cone-shape, through the film image, on every side of the lens. This uniformity can only be achieved if the light collecting mirror is absolutely *round,* and absolutely *on optical axis* with the *lens'* optical axis. Being off-axis causes color fringing and less light loss. A slightly non-round mirror can cause serious problems in the anamorphic lens and its distance adjustment. Although this topic has previously been mentioned in issue #H-50-29, optical alignment is a *must!*

Because it is an *optical* adjustment, the only accurate alignment method in current use is optical in nature, with a fine-line laser, mounted in a 'lens-sized' collar and adjusted for exact concentricity between the laser light-line and the outer collar rim. This laser is installed in the lens holder, pointing back toward the collecting mirror, which holds a precision target with several edges or locators touching only the polished inner mirror surfaces. The target includes a deep center tube concentric with the system, and having a very small mirror dot at the end of the tube which reflects the laser beam back on itself. This tube creates an accurate optical axis of the collector. When collecting mirror position-and-tilt is exactly located, the laser line will reflect back and be seen on the back of the laser. Then you get exact alignment, with the most light and the least color fringing.

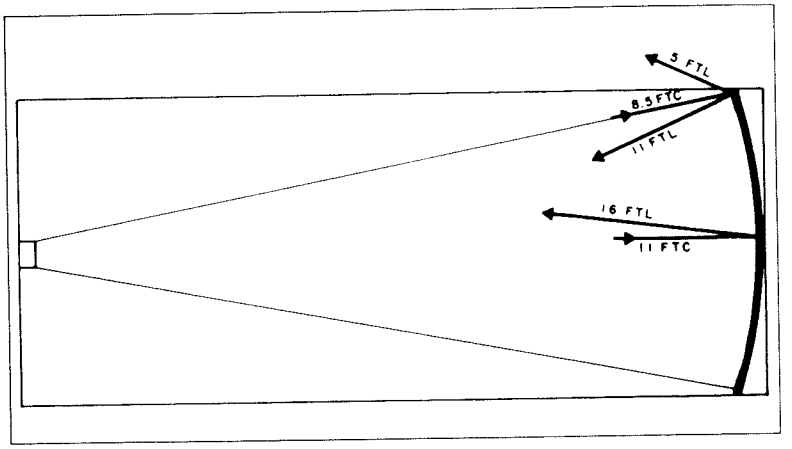
After exact optical alignment, the lens (especially with anamorphic format) will show which corners are out of focus, and then the projector gate will need to be adjusted or shimmed to eliminate the out-of-focus corners.

Second, the film image *shape* is not flat, but deformed by the hot-light beam, and must be

shape-cancelled by the design of the lens, so that an actual flat screen image can be developed. With the commonly used curved gates in Century, Simplex, and similar projectors, and with 2000 to 3000 watts of xenon power, the film shape is depressed, not quite spherically, with the center-sag away from the lens, and perhaps 0.006″ to 0.009″ deep in the center, depending on the amount of energy the film absorbs. The deformed film does not necessarily conform to the curve of the gate. The lens must be designed with a sufficient opposite field curvature so that this deformed film image is cancelled in the lens to become a flat wave-front as it approaches the screen, otherwise some parts of the image will be out of focus. (In older flat-field lenses, the deformed film image is accurately projected with a curved wave front, aimed away from the audience, forcing the corners to be out of focus.) If the deformation is cancelled by the lens, this still does not guarantee every corner.



Flat White "Gain" Screen (1.45 Gain).
(FTL – Foot Lamberts, FTC – Foot Candles)



Curved "Gain" Screen (1.45 Gain).

It is assumed that the four corners of the image are in a plane perpendicular to the optical axis of the lens. But with the non-symmetric 35 mm film image (having a sound track on one side), this is *not* the same as having the lens axis perpendicular to the gate rails. After exact optical alignment, the lens (especially with anamorphic format) will *show* which corners are out of focus, and then the *projector gate* will need to be adjusted or shimmed to eliminate the out-of-focus corners. The usual focus problem on the screen will be the right hand side, when the center and left are in focus properly.

Third, the lens designer has aims for image quality (sharpness or resolution), and if the resolution can not be obtained, with a very large aperture (such as f/1.7), the design must be closed down, perhaps to f/2.0, in order to eliminate the apparent center-screen soft-focus which is caused by film flutter. In the usual two-cycle exposure of every film frame, this flutter is most obvious in the center of the image. In past years, some lenses had 'stops' installed to improve the screen image, and these stops actually did nothing for the optical quality of the lens, but "covered" the film flutter, making it less obvious to see on the screen. The ESRAM (European Super Resolution Air-Spaced Multi-Coated) lenses were initially made for this reason at f/2.0 in the 1978-1980 era to actually improve the optical quality and "cover" the flutter in the design. With later designs such as the Ultra Star, many of them are nearly f/2.4, to maximize optical quality and further minimize the visual effect of film flutter.

This last item of film flutter is caused by the action of the heat in the light beam with the design of the shutter. For instance, having no heat filter and a 3-bladed studio shutter does yield minimum flicker, but can create more objectionable film flutter. This added film flutter can obviously 'soften' the center image, as compared to a situation with an *effective* heat filter (separate from the collector mirror) and a two-bladed shutter. There are several Hollywood area movie theatres with *better* screen image resolution on a 32′ wide anamorphic image than nearby Hollywood studios on 16′ wide images, because the studios typically use three-bladed studio shutters.

B. *How to Select a Lens for a Specific Situation*

There are big screens and small screens, there are 1.85 widescreen or Academy 1.37 or 35 mm ('scope) 2.35 formats. There are situations that require more light, and some which require more image quality. Even for 70 mm film, the needs are different. One lens can not suffice for all purposes! How should the proper lens be selected?

First, if the projection booth location has been fixed, and the screen/picture size has been determined, then the lens must have a specific focal length (see section E) for each format size. Given that a lens is available at that focal length, select a back lens for anamorphic different than a 1.85 lens. With 1.85 format, which is inefficient with light, you might need a larger picture width but more light efficient, or you may need more focus stability so you might choose a lens of f/2.4, or have a stop installed to reduce light a bit, and 'cover' film flutter. The aim is to achieve equal light level and equal image resolution within good practice and Industry Standards. In case you have need for the old 1.37 Academy format, it is easy to focus but much more inefficient in light (for constant height, that is), you might need a lens substantially 'stopped down' to reduce light level to a tolerable level.

In past years, some lenses had 'stops' installed to improve the screen image, and these stops actually did nothing for the optical quality of the lens, but "covered" the film flutter, making it less obvious to see on the screen.

Second, the lens should be chosen with the screen in mind; and, of course, select a screen with the lens in mind. If you require a gain screen, curve it with the formulas in SMPTE RP-95, or use a computer program to design the curve. If the screen is a shallow curve (perhaps curve depth about 10% of width), then the ESRAM lenses will work equally as well on a flat screen. This was considered when lenses were designed. If the screen curve is far more than 10% of the width in center depth, then special lenses might be required. Some specialists use a MagnaCom 65 with a longer lens to provide a bit of negative distortion (pincushion) to have the image fit the screen better, and then the image field curve can be slightly adjusted in the MagnaCom. Such needs are rare, and you should ask qualified specialists for aid. If the 1.85 focal length is short (less than 75 mm), the light rays are steep at the sides, and make use of a *flat* "gain" screen undesirable. If flat, use matte screen (gain = 1.0) for these installations.

Third, even though older Kollmorgen or Bausch & Lomb lenses had a good optical value for their time (designed for the Academy 1.37 format), avoid using them today, because they have only about 50-60% of the resolution of modern ESRAM lenses. This is especially true of any older, cemented element lenses, with focal lengths less than 4½" for 'scope or 3" for 1.85" where the picture might seem large to a close audience, and the lower resolution will become obvious to the viewers. These older lenses had much more flare and color fringing than modern multicoated lenses.

Fourth, for 70 mm film use, you must have a lens with generous image diagonal 'pass-thru ability' (entrance pupil). A lens designed for 35 mm formats will provide dark corners for the 70 mm format! The older Kollmorgen or Bausch & Lomb lenses in 4" diameter, with focal lengths of 5 to 9" can usually do well with 70 mm film. In the 1959-1975 era, the ISCO T-Kiptagon lenses were used Today, the best resolution and contrast are obtained by ESRAM lenses designed for 70 mm film and so marked on the lens in the normal 70.6 mm or 2.781" barrel diameter. These are usually the 105 to 150 mm (4" to 6") lenses, multi-coated. Below 105 mm there are special lenses made only for 70 mm film, such as the Schneider 70 mm Specials, and the ISCO Ultra Star 70 group (74 to 11 mm range). To show the obvious difference in design, the ISCO Ultra Star 85 mm lens for

If you require a gain screen, curve it with the formulas in SMPTE RP-95, or use a computer program to design the curve.

35 mm film, has a back window of about 1¼" diameter, while the ISCO Ultra Star 70 lens for 87 mm focal length has a back window of well over 2" diameter! This extra-large entrance pupil permits uniform illumination of the 70 mm format.

Be suspicious if anyone suggests that you can get a 'special-ground' lens for your requirement at the same price.

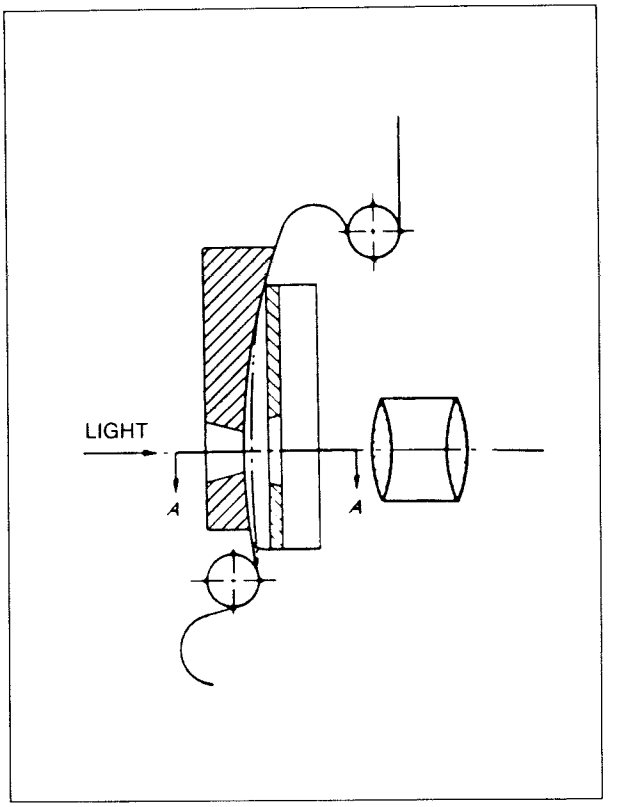
Fifth, be suspicious if anyone suggests that you can get a 'special-ground' lens for your requirement at the same price. In my 30 years experience of getting more than 30,000 lenses to market, only about a dozen were 'special-ground' and cost many thousands of dollars each.

C. *Off the Edge—Where do the Focal Lengths Stop?*

Unlike any other photo-industry, the theatre industry has had more choices in focal lengths. For photographic uses, a camera system might have 10 or 20 lenses for different uses; for 16 mm film projection, there might be 15 lenses. For 35 mm movies there might be two or three times that.

For the cinema, over the past 50 years, just for 35 mm film there has been a total range from about 12" (310 mm) then, to below 1" now. With each passing decade, the focal lengths have shifted shorter depending on new architectural plans, or changes in film formats. Such a range might easily include a basic 30 lenses in existing metric lens lines, plus the inch sizes over the years between 1¾" and 12" that would total 44 added focal lengths. Of course, there were separate lenses for 70 mm film use that would add dozens more. The choices seem nearly endless, but at each end (longest or shortest) is the last item, or 'the edge' beyond which there is *nothing*.

Before 1953 (the year Widescreen arrived in force), the common short lens was 3½" with a few new lens series having 2" to 3¼". Famous theatres changed when the Widescreen Cinemascope and the 'other' widescreen ratio of 1.66 to 1.85 arrived. Radio City Music Hall in New York has a 195 foot projection distance (20° down-angle), and with the 'old' Academy format having a screen image of 20' x 27' the lens in use was about 6". In 1953, the



Attitude of film in curved gate.

Cinemascope picture became 29' x 68' using a 4¾" lens (120 mm), and later when 1.85 became common, they used 3" (75 mm). But being Radio City Music Hall, they had a lens cabinet with perhaps 50 or more lenses for every possible film application, suiting their use of film mixed into their stage shows.

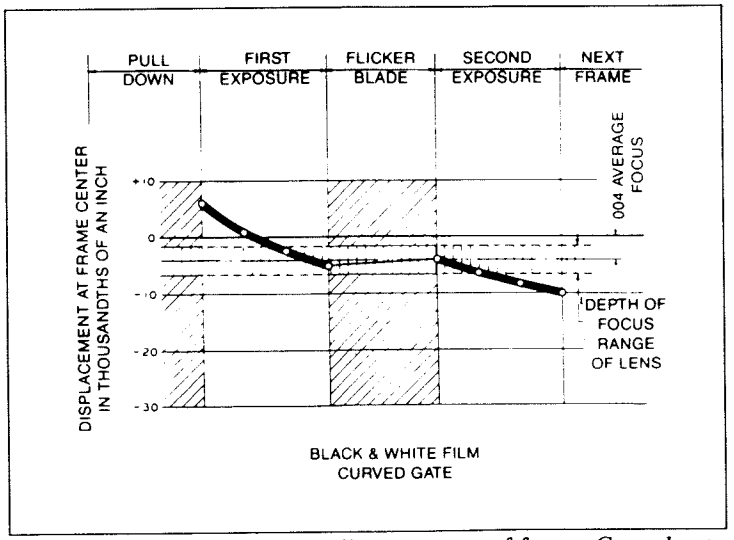
The trouble spot for projection lenses was the drive-in theatre. They needed the maximum amount of light for the huge screens which were often installed too far away. Although the best combination for the most light in a drive-in during the mid-1960's was a Kollmorgen 4" f/1.7 for 'scope and 2½" f/1.7 for the 1.85 format. These lenses were optimum for small screens of 32' x 75'. These lens sets were to be used at a distance no greater than 185' away from the screen. Unfortunately, many drive-in screens were as large as 50' x 120', and the layout called for a projection booth at the back of the ramps (perhaps 630 feet away), so that the lenses needed were 5½" for 1.85 and 8¾" for 'scope. Because this latter lens was a custom order, the reverse anamorphic appeared. This lens was designed to squeeze down the height rather than spreading the width. This reverse anamorphic could be used with 4¼" or 110 mm, which were readily available. The true maximum was a drive-in near Boston which required

a huge 4" diameter 11" lenses made specially for 70 mm use. Of course, with the demise of the drive-in (usually due to land costs), these extra-long focal lengths are not required at present.

Avoid lenses made with mounting barrel diameters other than US standard of 70.6 mm (2.781"). They are probably not suitable for the purpose, or are made by a lens company long out of business.

For 70 mm film, special lenses are required so that the huge diagonal of 70 mm (2⅛") which is twice the small diagonal of 35 mm (1.09") can actually pass through without dark corners. This normally requires a large entrance 'window' at the back of the lens, often as large as the film itself.

Because 70 mm films (since 1955) were normally on large screens in modern theatres and short projection distances, the need was always there for shorter focal lengths. In 1990's, with the theme park and World Expo designers, the lenses for 70 mm film have reached to a full 210° (14 mm), and even a 'fisheye' panoramic lens for 360° (full circle) projection from a single 10-perf frame of 70 mm film has been developed. For 70 mm film, there are more lens choices for short focal lengths than any other film format, although some are quite expensive.



Film displacement due to buckling at center of frame. Curved gate.

In summary, for 35 mm non-anamorphic (1.85 widescreen), there are lenses from 22 mm to 220 mm; for anamorphic ('scope), lenses range from 50 mm to 220 mm, and for 70 mm film from 21 mm to 150 mm (not including the 360° lens). There is a great range, with the often discussed 'barrier' for anamorphic lenses at 50 mm although there are custom high-cost lenses between 35 and 48 mm for specialty venue.

D. *Do you Have the Wrong Lens for the Job?*

This part of the article can be short, because with the modern ESRAM lenses, you can hardly go wrong. If the focal length you need is short and does not exist, use a Magna-Com with a longer lens to obtain some picture adjustment range. *Avoid any 4 element lenses,* usually in a black barrel. *Avoid cemented lenses,* which can discolor or get 'stars' in the middle. *Avoid lenses made by lens companies out of business,* because you can not get service or factory advice. *Avoid lenses with older 32-thread designs* for anamorphic use. If you need a thread ring, you probably have the wrong lens.

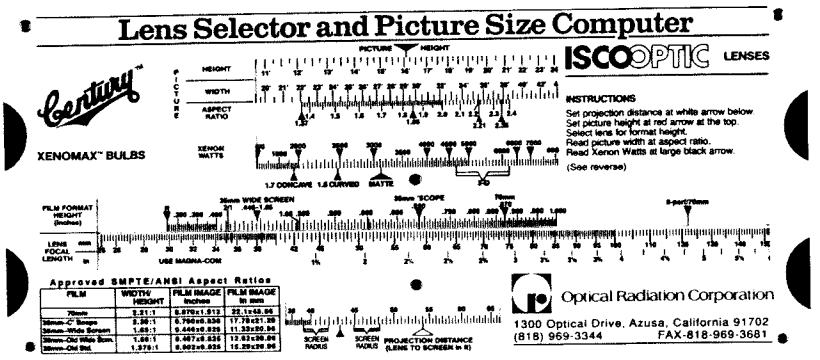
For 70 mm film, any of the regular ESRAM lenses between 35 mm and 9 mm *will not* handle 70 mm film properly, unless factory engraved for 70 mm film use. Use only a lens designed and marked for 70 mm film use. It will be the right companion for the $30,000 projector that's installed.

Avoid lenses made with mounting barrel diameters other than US standard of 70.6 mm (2.781"). They are probably not suitable for the purpose, or are made by a lens company long out of business. For larger screens consider reduced f/number lenses. Although it's nice to have extra light from a 'faster' lens, the larger magnification on larger screens reduces depth-of-focus and can reduce image quality. In other words, avoid 'fast' lenses for 35 mm on large screens!

E. *How Is Lens Focal Length Calculated?*

If there were only 5 or 6 lenses in use in the industry, we could mark them A, B, C, etc., but with so many available, the optical design factors (such as focal length) are

used to define the magnification results of the lens. Of course, for the same format at the same distance, the 70 mm lens will provide a screen image twice as large as a 140 mm lens, and the 35 mm lens will give twice as large a picture as the 70 mm focal length will provide. Larger formats provide larger pictures, and greater distance to the screen provides larger pictures.



Lens Slide Rule–Back

Definition: for a single element lens (like a magnifying glass), if you focus the lens, with the sun's rays to a focus point, the distance from the center of the lens to the focus point **IS** the focal length. With a multi-element lens the focal length remains the distance from the center (nodal point) to the focus point. What is more important is that the focal length can be used in formulas to estimate screen image sizes when the film size and projection distance is known. In the formula, the focal length is given the term of Effective Focal-Length or E.F.L. as follows:

$$\text{E.F.L. (in mm)} = \frac{\text{Projection Distance (feet)} \times \text{film image width (inches)} \times 25.4\ \text{mm/inch}}{\text{Screen Image Width (feet)}}$$

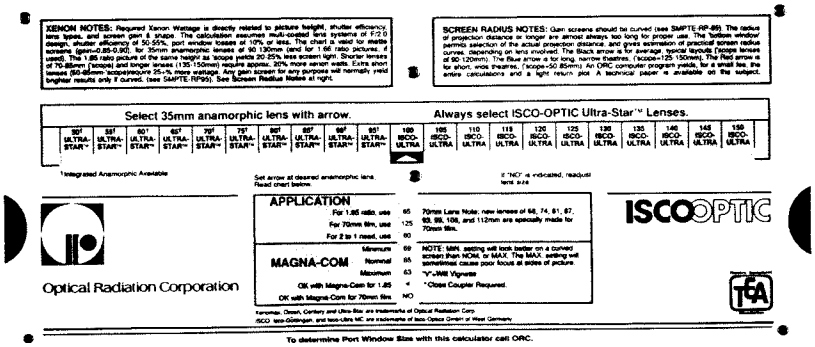
This can be rearranged into many forms, and the heights can be substituted for the widths. In daily use, however, most planners use one of the 'Lens Slide Rules' that were provided by Kollmorgen (1966), Goertz (1970), Schneider/ISCO (1975 & 1978), and Optical Radiation/ISCO (1984 & 1989). Each is designed so that the inputs of **Projection Distance** at the bottom 'window' and the estimated **Screen Image Height** at the 'top window' can set up the rule so that many formats and lens possibilities can be reviewed at once. Often it is required to adjust the **Screen Image Height** so that actual lenses can be involved, and not find a focal length which has no real lens available.

There is a caution in using the Lens Rule, in that it is for calculation to about 2 or 3% accuracy, but in some cases that might be several inches, so consider these cautionary factors.

1. For *very* short lenses on large screens, obtain technical aid, since the formulas for lens calculations are not truly valid with really wide-angle projection, which should be calculated in degrees and not feet or inches.

2. For "floating screens" where there is no possible adjustment with edge masking, be sure to double check each dimension–perhaps by computer–to avoid costly mistakes. Computer programs of this set of calculations exist, but the errors are often in the measurements of the auditorium.

3. Consider that the industry lens standard SMPTE #243 specifies a focal length tolerance of ±1%, which in a 40′ screen width is ± 5 inches. So the formula or slide rule cannot provide the exact answer for a given lens.



Lens Slide Rule–Front

F. *Is F/Number a Problem?*

The f/number defines the angle of the input light cone to a lens, that will 'pass through.' For example, for the lamphouse, a 12″ diameter mirror at 24″ from the lens would be 24/12=2 or f/2.0. That also can be expressed as an *angle* of light entry. When the lens is

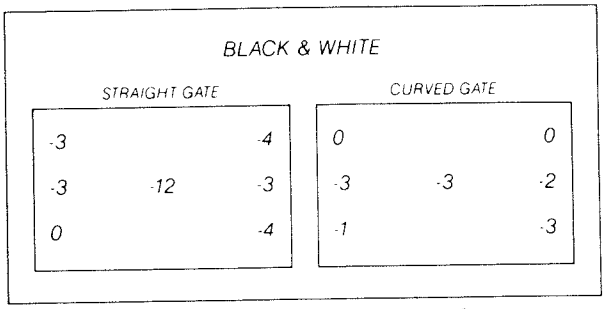
designed, the designer can determine the entrance angle limit, which also determines certain optical characteristics. The larger (or 'faster') the input angle, the greater the optical problems in the lens design; in other words, an f/1.6 lens has several categories of problems which are substantially more difficult to solve, than for an f/2.0 lens.

When higher gain screens (anything over 1.2 gain) are mounted on a flat screen frame, the hot-spot created is usually offset by the projectionist adjusting the lamphouse to "flatten" the light.

Lenses designed between 1946 and 1961 included f/1.4, 1.5, 1.6, 1.7, 1.8 and f/1.9, and often had soft focus, color fringing and other optical problems.

If light level is a problem, an f/2.4 lens when replaced by an f/2.0 lens should increase the light by 10-20%. However, there will be image quality loss at the same time. It may be wiser to install a larger lamp to increase the light levels to meet the standard (SMPTE-196), than reduce image quality.

The f/number area is filled with compromises, and should be discussed with experts in the field before too much time is wasted in theatre experimentation. They can help decide if the best option is a faster lens, a larger pump, or a curved gain screen. Perhaps a careful adjustment would do it!



Across-the-screen focus conditions. Straight gate against curved gate. Numbers are thousandths of an inch lens displacement.

G. *What Can the Lens Do about Picture Unsteadiness?*

The lens, *with the speed of light*, will provide the image on the screen. If the film image moves in the projector, the lens will absolutely show that motion on the screen. If the screen IS large, or, because you are close, it *seems* large, then the unsteadiness will become obvious if not annoying. Assuming that the lens is firmly clamped in place, unsteadiness is a matter entirely between the film and projector; with the lens totally unable to cope with or correct the problem. Unsteadiness is caused by thermal affects on the film and mechanical problems in the gate/trap area. Unsteadiness is usually affected by gate adjustment, film wear, film lubrication or other mechanical factors, some of which may be improved by adjustment.

H. *Are Lenses Used to "Mask" Other Problems?*

Certainly! The entire problem of film flutter is expected to be "masked" by the lens. Although the film flutter was described and reviewed in SMPTE technical papers by Dr. Fred Kolb of Kodak and Willy Borberg of Simplex (even before the 1953 widescreen revolution) there seems to have been no R & D activity on the matter to remedy it. If film flutter were completely eliminated, a new approach could be made with projection lens design.

Further, some xenon lamphouse problems have been blamed on lenses. When two-mirror xenon lamphouses were popular in the late 1960's and early 1970's, misadjustment between them could easily produce a double image on the screen. Although such older lamphouses are rarely used today, there was much discussion as to why the "lens would allow that to happen."

When higher gain screens (anything over 1.2 gain) are mounted on a flat screen frame, the hot-spot created is usually offset by the projectionist adjusting the lamphouse to "flatten" the light. This actually *misadjusts* it, so that the lamphouse is not at best efficiency, and the lens is provided with a sort of doughnut-shaped light intensity (weak in the center), which begins to violate some of the lens assumptions made by the designer. This can easily make softer focus or add color fringing that should not be there. Curved screens as introduced in the 1950's by the studio engineers conquer these 'misadjust' and hot-spot problems.

I. *Use of Lenses on Curved Screens or Flat Screens*

Although everyone understands the shape of a flat screen, curved screens fall into several categories. Although the use of curved screens in new theatres is rising, they are frequently misunderstood. To be most reflective, there should be uniform incident light (just before it reaches the screen); with this uniformity, if there is a 'hot-spot' seen from the middle seat, the gain and screen shape are not correct. There are several types of curved screens:

First, there is the category of the wrap-around curved screen, first seen in the Cinerama process. The aim was exclusively to provide the wrap-around impact, and not for any reflective purpose.

For instance, if film flutter were eliminated, different xenon lamphouses could be made and different lenses designed so that the whole process could be more efficient.

Second, there are rule-of-thumb curved screens, such as curving at the radius of projection distance, or not exceeding a 12-inch depth. This might improve the light return somewhat, but it is only a partial curve, and with only partial results. There are few if any problems in focus with this screen design, using ESRAM lenses.

Third, there are cylindrical screens resulting from computer ray-trace programs, which still are shallow, but the main effort is to cause proper reflection toward the center seating area. This works well for reflection improvement, except for shorter lenses, which leave the top and bottom of the screen reflecting toward the ceiling or floor. Again, with minor exceptions, there should be no focus problem with ESRAM lenses.

Fourth, there are concave or compound curved TORUS screens which are computer ray-traced so that the entire screen is gain-reflective toward the center seating area. In other words, the 'hot-spot' has been spread, by screen shaping, to the very corners of the screen vastly improving its light return efficiency. Again in these situations, the screens are shallow, and with minor exceptions should not provide any focus problems.

For the deep-curved Cinerama-type screens, special lenses should be used so that proper 35 mm and 70 mm projection can be accomplished with good focus. Such screens are rarely used today.

J. *Future Possibilities for Lenses*

When the concept of "System Engineering" can be accomplished for film projection, other types of lenses can be designed. For instance, if film flutter were eliminated, different xenon lamphouses could be made and different lenses designed so that the whole process could be more efficient. For example, a 2000-watt xenon could properly light a 40′ wide screen.

Further, if film flutter and film unsteadiness were eliminated, the lens would be clamped in place never to be focused again. (Today, focus needs to be checked periodically because of film differences caused by focus flutter, humidity variations, center core 'set', etc.)

If the 'universal' concepts of projection equipment were eliminated, the shutter could improve, the lenses could be "fixed" focus, and the systems would be much more efficient. For example, if a special 35 mm theatre were designed for a 30′ x 60′ hi-impact screen show and viewed closely, the calculations would indicate that it would take 6000 to 7000 watts to illuminate it properly; but with integrated designs for screen, film format, projector and lamphouse, it could be readily done with 4000 watts with full illumination.

In the late 1970's, the idea of a 50 mm anamorphic was considered not to be possible, but in the 1980's such a lens was created as the integrated anamorphic that also fit rotating turrets. It is readily available today. Even in the late 1970's, reaching the entire target resolution on the RP-40 test film (up to 80 LP/mm) was considered impossible, but it is easily achieved in many theatres now. But the movie industry does not have a quality standard for projection lenses. An overall picture quality test ought to be required for professional theatres.

The future holds what Hollywood and exhibition will permit to happen. R & D, although unfunded, could provide more 'magic.' When more "lens magic" is needed, it *can* be accomplished relative to 'faster,' retrofocus, shorter focal lengths, 'fixed' focus, and so on. *The future is what we make it!*

To order the Lens Selector and Picture Size Computer, contact Barbara Stokes at Optical Radiation Corporation, 1300 Optical Dr., Azusa, California 91702, (818) 969-3355.

Holiday Toys and Greenberg

Adam Greenberg has a special gift for audiences this holiday season: it's called *Toys*. It is an abstract fantasy film co-produced, co-written, and directed by Barry Levinson for his own company, Baltimore Pictures. *Toys* is distributed through 20th Century Fox and stars Robin Williams.

Cinematographer Greenberg had never worked with Levinson. "When they called my agent and asked if I wanted to read the script, I was elated," recalls Greenberg. "I loved the script and the story. I wish we had more like it. I knew Barry to be an intelligent director who has the reputation of giving his cinematographers the freedom to make creative contributions. I have dreamed of working with directors like Barry."

It was an 82-day shoot. All but six days were spent on gigantic sets at Fox with elaborate props and mechanical keys either driven by remote control or suspended from guide wires. There was a huge miniature set of Manhattan with more than 200 buildings. It was so complex that lighting required hundreds of miles of cable. The set was so crowded that the electrical crew had to work in a pit under the stage.

The musical scenes in *Toys* challenged Greenberg with as many as 250 extras, whose movements were precisely synchronized, like an old-fashioned music box.

In one memorable setting, Williams and his uncle, who become adversaries, are strolling through the toy factory, with frantic activity going on around them. Greenberg is lighting from above, using large panels of white cloth to diffuse the light and gels to add color. It's a precisely-choreographed ballet with everything moving in lock-step – the actors, the extras, the cameras – while Greenberg orchestrates the quality of light by opening and closing the panels.

Two cameras were used on most of the production, although the big scenes involving many extras sometimes required as many as five separate cameras. To make the demands even more intense, Greenberg had to keep pace with an unrelenting schedule. He shot some 15,000 feet of film in a typical day: 42,000 on one particularly grueling day, and an amazing 1.2 million feet in all!

Adam Greenberg, ASC

"We could have done the same thing with half as many cameras, but it would have taken twice as much time," he explains. "This was better. It made lighting more complicated, but there was a lot of spontaneity that you don't get if you re-shoot a scene too many times." Production time is precious and spent cautiously. Adam recalls: "I was totally immersed. The only time I saw daylight was when I walked to dailies, five minutes there and five minutes back."

Greenberg was called upon to light large, intricate sets which were designed and built before he was hired. Most of them reached the perimeters of the stage walls. They all had ceilings. And Levinson had a penchant for showing the audience the floors, the ceilings, and the walls, so they believed the reality of the settings. Greenberg's resourcefulness was perpetually required to find places to hide lights, particularly with at least two cameras prowling the sets on cranes and a director calling for a full 360 degrees of coverage.

"One day, Barry returned from an editing session, and asked where I hid the lights. He and the editor couldn't figure it out." Greenberg smiled at him and went back to work.

But it was the intellectual creativity which made the film so interesting to shoot. *Toys* borders on the abstract, but it is not a fairy tale, and does not have a *Dick Tracy*, comic-book look. There is an invisible line between fantasy and reality, and Levinson straddled it with a foot on both sides.

That raised many questions for the cinematographer: how do you show the audience toys that

are menacing and dangerous? Are the toys lifelike or machines, and how do you get that idea across? What do you do about visual perspective when the toys are usually at ground level with the actors towering over them? And how do you deal with the ever-changing gray area between fantasy and reality? For answers and guidance, Greenberg drew upon a lifetime of experience and a bedrock of instincts.

Adam Greenberg immigrated to the United States from Israel in 1980 with 120 documentary credits in his portfolio. He had shot more than sixty features as well, three of which earned Oscar nominations for Best Foreign Film. Despite the element of risk in beginning again, he had a strong desire to apply his considerable talents in cinematography to American-made films.

"I knew I could never be satisfied unless I tried working in Hollywood," he reminisces. "I believed in myself and my family believed in me. I could never have done this without their support. I had to take a chance and see if I could make it in Hollywood."

Greenberg sold what he owned and moved his family to Los Angeles. "I had no job promises, and very few connections. I visited every agent in town and was encouraged by no one."

He got his first job on a low-budget feature by sheer persistence. The second film came easier through good word-of-mouth. His first big box office hit was *The Terminator.* Jim Cameron, who was just beginning, saw something he liked in Adam's work.

"After that everyone wanted me to shoot their action films," Greenberg remembers. "I learned to wait for the right film with a story to tell. I don't have a particular style. Every movie is different; each has its own look."

Greenberg has amassed some 30-plus credits since moving to the West Coast. In addition to the aforementioned films, they include *La Bamba, Alien Nation, Turner and Hooch, Near Dark,* and *A Woman Named Golda.*

Following an early stint at shooting black-and-white newsreels, Greenberg stepped up to mini-documentaries, sojourning to many locales in the world. He shot and produced 13- to 14-minute films which told stories with pictures and wild sound. Usually, he had just two weeks to shoot them working with 35 mm color film. These provided opportunities to experiment with different styles of visual story-telling. He learned about capturing the moment of truth on film in terms of natural light and realistic staging.

Greenberg shot his first narrative film in Israel during the early 1960's when he was still in his mid-twenties. For years, he alternated between documentaries and features. In 1974, he shot his first feature film in Europe and continued to work in features thereafter. They were low-budget by U.S. standards. He usually operated the camera himself as well as lighting the scene. This dual responsibility taught him more about the composition and camera movement. But today he prefers the U.S. crew system where camera operator and director of photography are separate functions. "That gives you the freedom to work with the director in helping to determine the look of the film," he says. "Most directors hire you for your experience. The other thing I have to offer is my vision. The directors I like to work with want me to look ahead and visualize how the audience will see their film. If you can get that picture in your head, it tells you how to shoot the film."

Early in *Toys,* there is a pivotal scene which establishes the basis of conflict in the collective mind of the audience. The owner of the toy factory is dying. His employees have been like family, some of them with him for thirty years. Every day of his life has been a pleasure, but he doesn't want everything he has worked for to die with him. His brother is a retired war general. He has a son (played by Robin Williams), but he doesn't think his son is ready for the responsibility of the factory, so he puts his brother in charge and asks them to work together.

The former general quickly learns that the public interest in spending millions on war weaponry is waning, so he recruits some of his old cronies to build high-tech war toys. They replace some of the loyal factory workers and take over the operation. That provides the basis for the son to step in. There are epic battles between toy armies. Tiny tanks and planes blast each other into oblivion. Williams flies a pint-sized toy plane into battle with a vicious toy helicopter spewing an awesome array of firepower. Greenberg used sixteen cameras to capture the scene!

"It was a very short take. We only got about 50 or 60 feet of film in each camera," Adam expounds, "but the flight looks like it goes on forever because there are so many cuts and angles. Five or six of the cameras were moving, some on crane extensions, some in crash boxes."

Greenberg's lighting challenges continued throughout. Williams' character's sister has an elaborate bedroom with a huge skylight. An important night scene captures clouds rolling by the moon sending dancing shadows into the bedroom. There was no place to hide lights on that set. Greenberg, together with gaffer Steve McGee, invented a solution. He had thirty special units made that were only two or three inches in length and were lightweight enough to adhere to the walls, furniture, and small niches. This allowed him to bathe the room in an aura of ambient light. He used fiber optic tube light to put a touch of fill on faces.

Color is a major element in setting the tone for the story. In the opening scenes, the colors are exaggerated warm pastels. As the story progresses, there is a transition to harsher lighting and stronger, more basic colors, cold blues, which are clearly defined. That helps establish the changing mood. Set design, costumes, and lighting were all ingredients in shooting the film. Greenberg expands upon his methods: "You have a plan for shooting each scene. You have to do that if you are going to keep on schedule. Every scene has its own look; its own best way to light. You also have to think about continuity and how scenes will play against and into each other. You have to consider that each character is developing and changing as the movie goes on."

Adam sees lighting as an on-going process that is always subject to change upon the flow of the film and the way the actors react to each other and the settings. "I have enjoyed my work more and more," he continued, "because I feel there is more freedom today with mobile cameras, faster films and lenses. I'll get an idea and turn a light off and look at the scene without it. I'll change my mind. I'll play with the lighting until it looks and feels right. I can trust my eye because I know the film is going to record the scene the way I see it."

Greenberg shot most of *Toys* on Eastman EXR 500T film 5296 with some exteriors on the EXR 100T film 5248. He also used Eastman EXR 50D film 5245 plus Eastman EXR 5297 for exterior daylight scenes. The main action was on those deliciously deep and elaborate sets at Fox. The usual set stop in *Toys* was T-4.5 to establish a consistent look. He rarely filtered the lenses except for color balance.

"I want consistency and tonality from a film stock," Greenberg says, "and I want to minimize grain because that gives me more freedom to control the look myself." There are mesmerizing illusions, as when he stretches the latitude of the 500-speed film while probing deep into the Manhattan set, creating images that extend for miles and miles.

Although Greenberg prefers hard light because it is more malleable, he uses all of the brushes available to him. He didn't hesitate to put a little soft light into someone's eyes to create a sparkle if that's what a moment needed. Sometimes he used smoke, usually as atmosphere in a battle scene. It spread the light, helping the lens and film to further explore the background.

There were scenes with as many as 30 toy tanks. Every move was painstakingly planned and rehearsed and Greenberg's input was considerable. Much of the coverage was shot at ground level with a snorkel lens which put the audience in eye-to-eye contact with the array of toys. In one scene, the audience sees a tank from Williams' perspective. The snorkel was barely two inches from the tank during the shot.

Greenberg experimented and discovered that shooting at low, wide angles at 48 frames per second added a feeling of weight and heaviness to the toy tanks. They were a bit distorted and more menacing. But there were times when he used longer lenses to compress and distance the image. There was a considerable amount of trial and error, including critical bits of action when miniature missiles are in flight to clamorous explosions. Adam tried shooting those scenes at 96 frames per second and at 64 frames per second. It looked terrific both ways, but what finally worked best when the toy missile tracking was put together with the background information was a slow 12-frame-per -second exposure. "The operator had difficulty panning and tracking on these shots," Greenberg explains, "but that was perfect. It was much more realistic. You could feel the speed with which these events were occurring. When you saw it on a big screen, it felt more realistic when it was shot that way."

There are many different levels of emotional content to this film. It has comedic aspects and action. There are dynamic battles, explosions, fire and utter destruction. Parts of the movie force the viewer to flex his mind and accept unlikely possibilities as reality. The audience is incredulous, like the set where the walls compress in on the characters. They begin at 25 feet and close to 6 feet apart, yet another ponderous cinematography lighting challenge!

There are good characters and evil ones in *Toys*. But the toys themselves never take on human attributes. They remain simply toys. The humans controlling them are the source of conflict. Clever cinematography helps the sinister war-monger brother to take on a larger-than-life presence, while Robin Williams' character is not "boosted" in this manner. There are no low angles or heroic lighting to help the audience identify the transition of his character: it comes from within. The trick is for the camera to come into intimate contact with the character without intruding. It takes a special actor like Williams to enable the film to gradually reveal layers of one's personality.

"In all of my work, there was never a movie that absorbed me like this one did," Greenberg enthuses. "There are many people to thank, my family, my crew, my cast, the lab (CFI). A movie doesn't end when you shoot the final frame of film." Like many contemporary cinematographers, Greenberg's contract carried him through the process of color timing and answer printing. It's comparable to a composer conducting his own symphony. In the final analysis, it is not just the individual threads of a film which define its worth. It's the magic of the whole fabric coming together. And *Toys* provides a coat of many colors with which to welcome 1993.

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