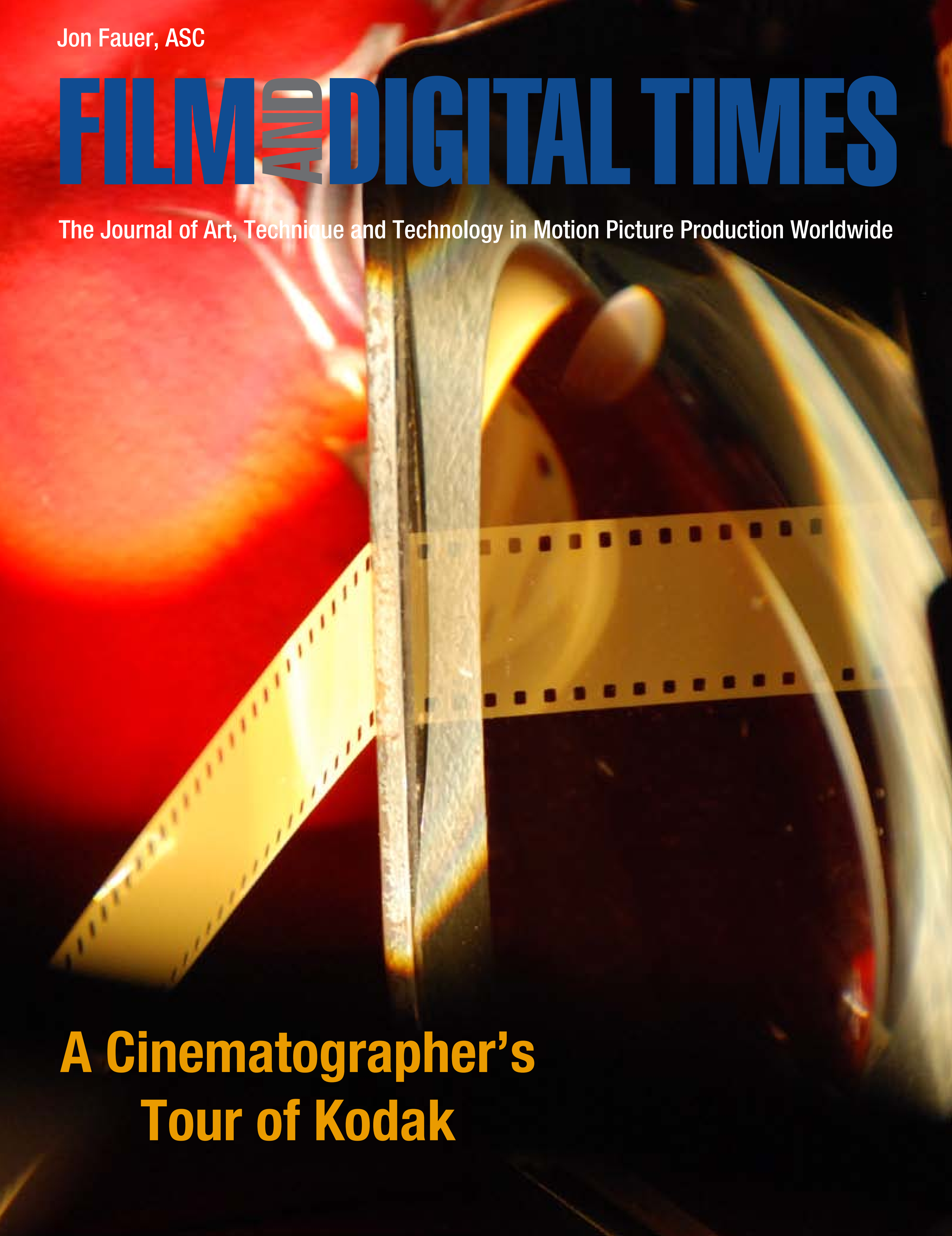
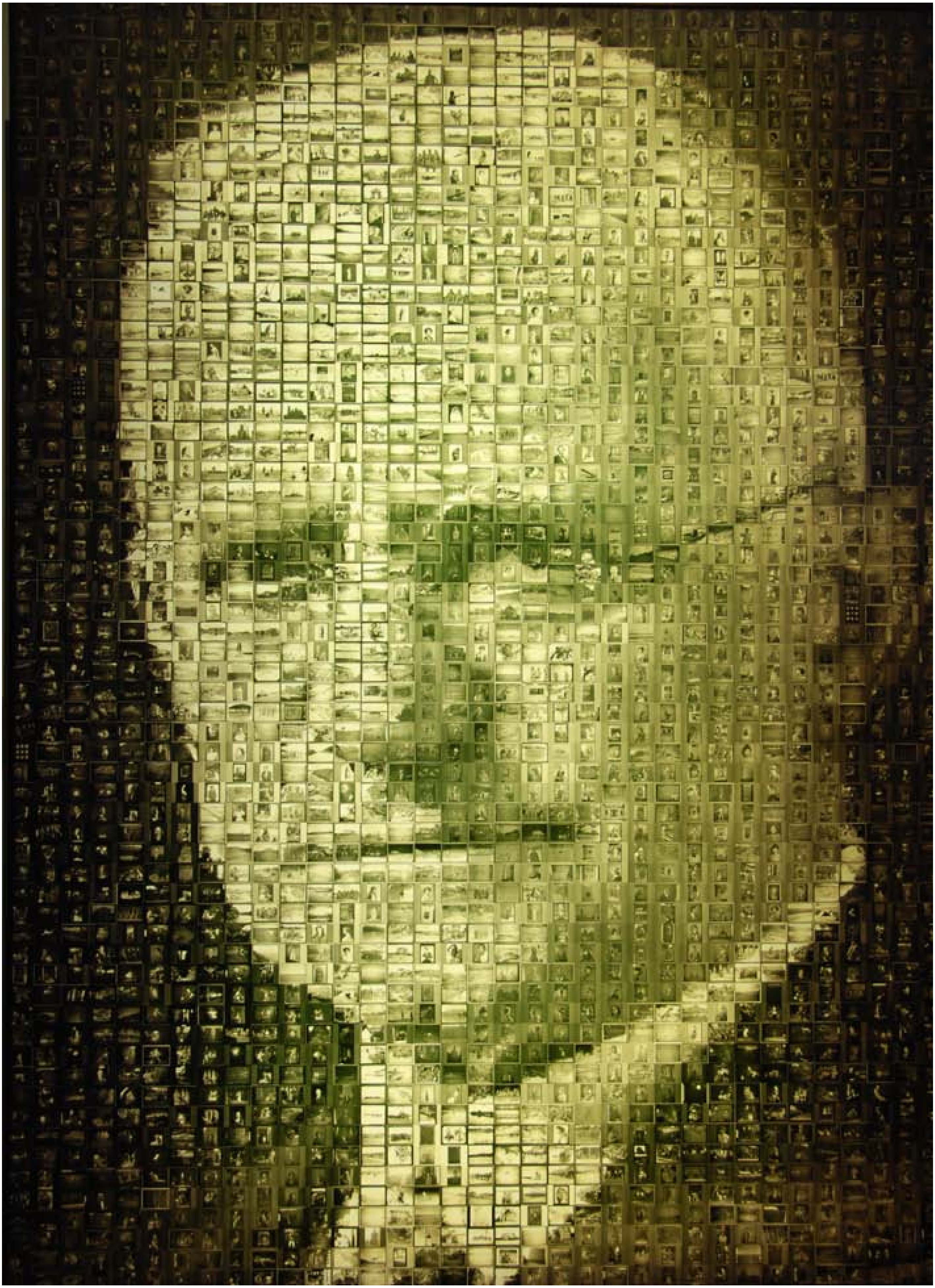
Jon Fauer, ASC

FILM AND DIGITAL TIMES

The Journal of Art, Technique and Technology in Motion Picture Production Worldwide



A Cinematographer's Tour of Kodak



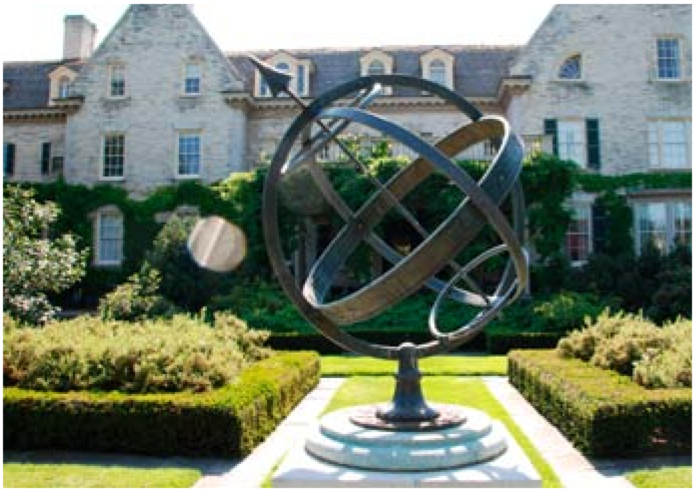
This report could be called, “My Trip to Kodak.” I was recently invited by Sarabeth Litt and Carolyn Delvecchio to join Michael Ryan, Garrett Kokx, Martha Le Cars, Bill Fekete, many Kodak scientists, and John Johnston (former Kodak Regional Sales Manager, and now associate at Film and Digital Times) to take a whirlwind tour compressing a hundred years of film manufacturing progress into a few fascinating hours.

This report is not intended to be a technical treatise on how to build your own film factory. There may be some omissions that could raise the eyebrow of a Kodak scientist, despite my having paid very close attention to the fascinating narratives of the best and brightest who escorted me through the impressive facilities in Rochester. My intent was to illuminate the process of film manufacturing so that fellow cinematographers and students might better appreciate the fascinating technology and process behind the product. The following report is one writer’s take on a private, privileged tour. I’m not able to cover every technical detail, but I do hope to help my colleagues better understand what is in the familiar round can.

A mosaic of George Eastman, composed of 2500 images selected from over 50,000 images, is on display at the George Eastman House collection in Rochester, New York. It uses computer technology developed at the MIT Media Lab by Robert Silvers to map a collection of photographs, assigning each to a particular location by their individual colors and shapes. The images we capture on film, store, print or project are mosaics of silver crystals that become tiny points of light. The smaller the dots, the sharper the image appears.

The genius of George Eastman (left, and above, with Thomas Edison) is that he developed a universal, flexible matrix, a worldwide standard that did many things: it was the sensor, the recorder, the storage medium (all uncompressed), and could be used to copy, archive and project.

George Eastman House



A busman's holiday is a vacation that involves doing the same thing that one does at work. A cinematographer's holiday involves a trip to Rochester, New York—to visit Eastman House and Eastman Kodak Manufacturing.

George Eastman House is not to be missed if you have anything to do with still or moving images. An easy one and a half hour flight from New York City or five hour scenic drive to Rochester, New York, it is the world's oldest photography museum and archive, and houses the world's largest collections of photographic and cinematographic equipment. The house, gardens and estate are a valuable National Historic Landmark.

It's a curious thing about Latitude. Degrees of Longitude are variable, but distance from the equator is a constant 69 miles per degree.

I have a theory about the Industrial Revolution. Technology was fueled not only by water power and coal, but also by parallel thought processes that coincided, around the world, with similar degrees of Latitude. Rochester, New York is 43.19° North. And it was here, in 1880, that George Eastman opened a photographic dry plate manufacturing company. Lyon, France is 45.75° North, a mere 177 miles apart in Latitude (but 3895 apart in Longitude) from Rochester, NY. In the same year that George Eastman worked by day in a bank and by night in his workshop, Louis and Auguste Lumière were engaged in similar painstaking work from 5am to 11pm in their father's failing photographic plate company. Two years later, both were prospering, and the rest was photographic and cinematographic history.

Today, you can visit the houses, now wonderful museums, of these entrepreneurial geniuses. The Lumière Villa was completed in 1902. George Eastman's Estate was built between 1902 and 1905. Although the Lyon house is Art Nouveau and the Rochester house is Colonial Revival, both share the owners' passion for light and abundant use of wide expanses of mullioned windows. George Eastman's 35,000 square-foot house, with 50 rooms, 13 baths and central clock system, sits on eight and a half acres at 900 East Avenue in Rochester. In 1919, he decided to renovate, and to improve the acoustics in the conservatory, cut the house in half to move it nine feet, four inches. It is a beautiful room, filled with light from the skylights above a model elephant.

The name "Kodak" was invented in 1888. Eastman liked the letter "K" because it was "strong and incisive...firm and unyielding." Elizabeth Brayer's definitive biography, *George Eastman*, quotes him, "First: It is short. Second: it is not capable of mispronunciation. Third: It does not resemble anything in the art...it is euphonious and snappy." To market the Kodak camera, he came up with the slogan "You press the button, we do the rest."

The Eastman Kodak Company revolutionized photography through simplification, standardization, and products that almost everyone needed or wanted. The flexible film that was 35mm wide with perforations along the edges helped launch the motion picture industry, and later converted it to color.

The museum displays an extensive collection of historic cameras. But for a special treat, let's visit the huge underground collection.

Technology Collection at George Eastman House

Most of the Technology Collection at George Eastman House is in vast vaults underground. You can't just walk in. This is by appointment only. It's like the end scene in "Raiders of the Lost Ark." There are 4,100 still and motion picture cameras, 700 projectors, 400 hand-held and stereo viewers, 900 lenses, and more than 4,000 items from the Eastman Kodak Patent Collection. If you're a careful cinematographer, they even let you touch the stuff.

Todd Gustavson has the enviable job of being Curator of the Technology Collection at George Eastman House, shown above with a Cinematographe at right and a water-cooled projector at left. At right: the rotating shutter of a Cinematographe.

There are lessons in film history. The 1895 Lumière Cinématographe advanced the notion that little cameras could shoot important films to be projected onto large screens for big audiences. Hundreds of Cinématographes were made. They functioned as a camera, printer and projector.

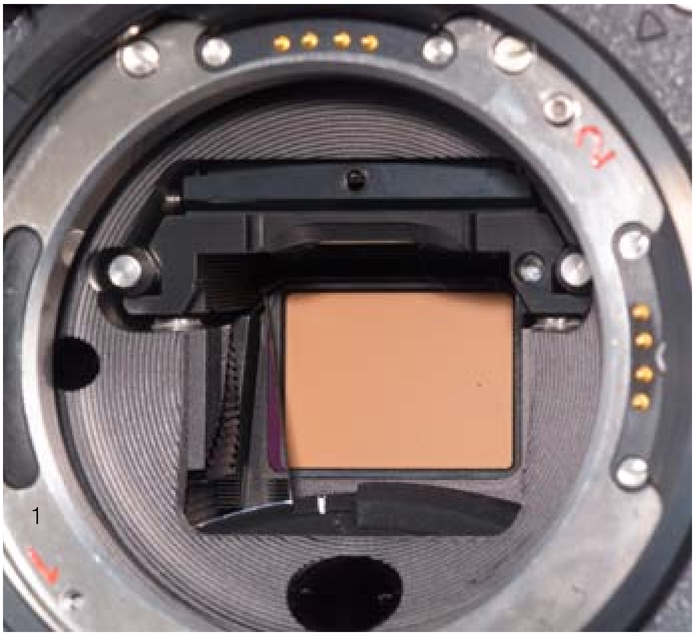
You could load a current film stock into almost any of the cameras at Eastman House and shoot today, not at 2K or 4K but at a resolution determined by the specifications of the scanner yet to be developed. As Rob Hummel has said, the great thing about film is, "all you need is a lens and a light." A 1917 Akeley camera, *below*.

Edison's Home Kinetoscope, *right*. A New York Times article from 1912 describes it: "Tiny Machine Has Non-Inflammable Film and Throws a Picture 2 by 1 1/2 Feet...This invention, which is the product of a great deal of labor and a great deal of money, is simply a miniature moving picture machine, a biograph that a child can handle. Its chief difference from the ordinary commercial kinetoscope lies in the fact that it is very simple, very compact, and that its films are non-inflammable.

Edison wanted the projector to show copies of movies produced by his company, not movies made by the customer. It used an 80 foot spool of 22mm film, printed in three columns.

The first Edison films (1895) were shown on Kinetoscopes in Peep-Show Parlors. One person at a time could watch the film, in a continuous loop, as it traveled over a light source and a shutter inside the cabinet.

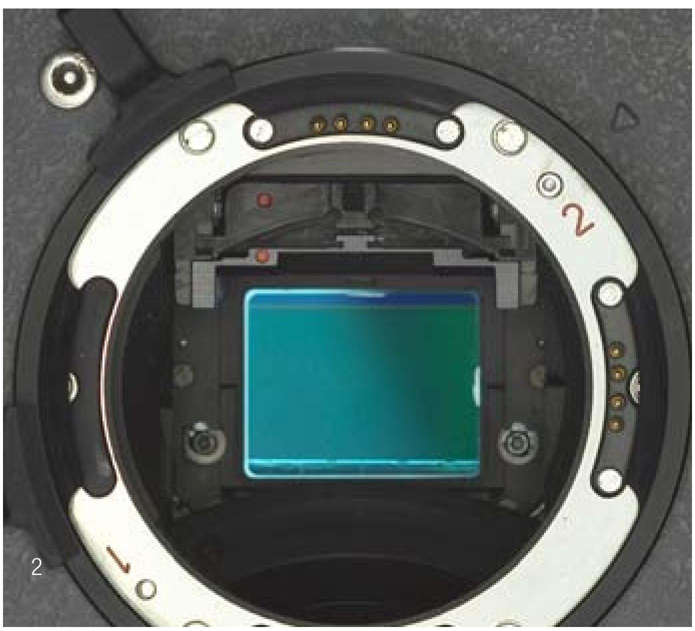
Film: A Universal Standard Sensor

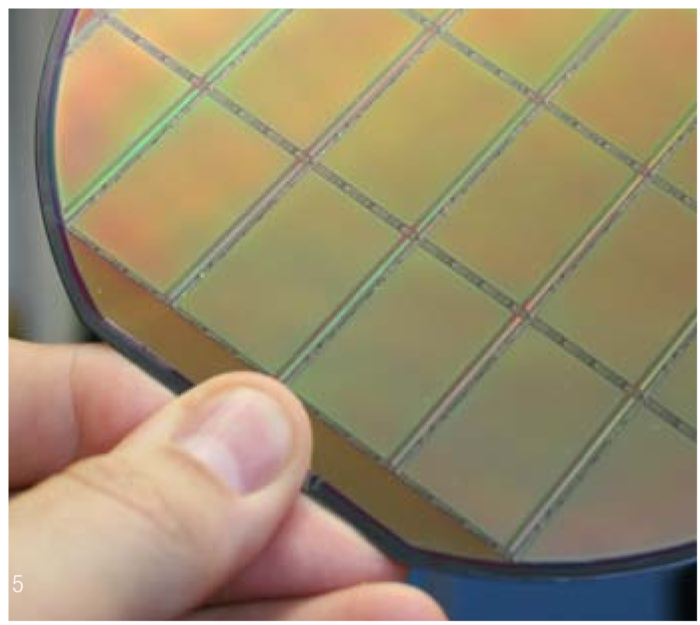


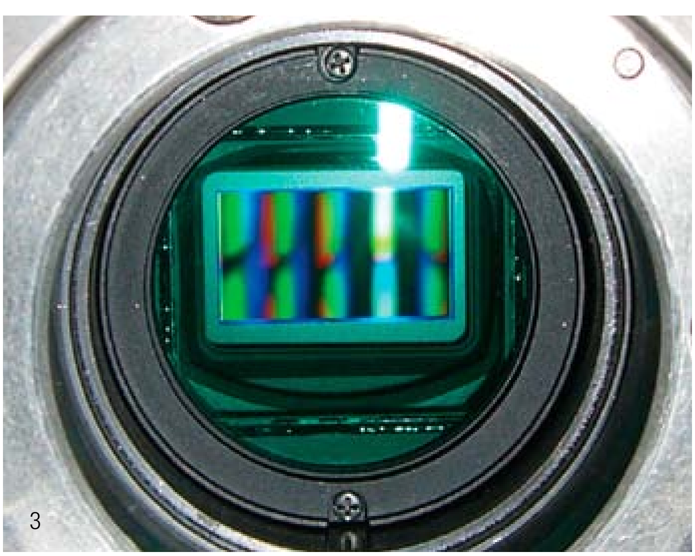
George Eastman became a very wealthy man by focusing not only on cameras but also on the product that would go in those cameras: film. Just as Gillette was interested more in blades, and Bill Gates more in software than computers, Eastman grasped the "big idea" of supplying the essential ingredient that everyone else required. During his lifetime, Eastman donated millions to the University of Rochester, MIT, the Eastman School of Music, educational and arts institutions, public parks, hospitals, dental clinics, and charitable organizations around the world.

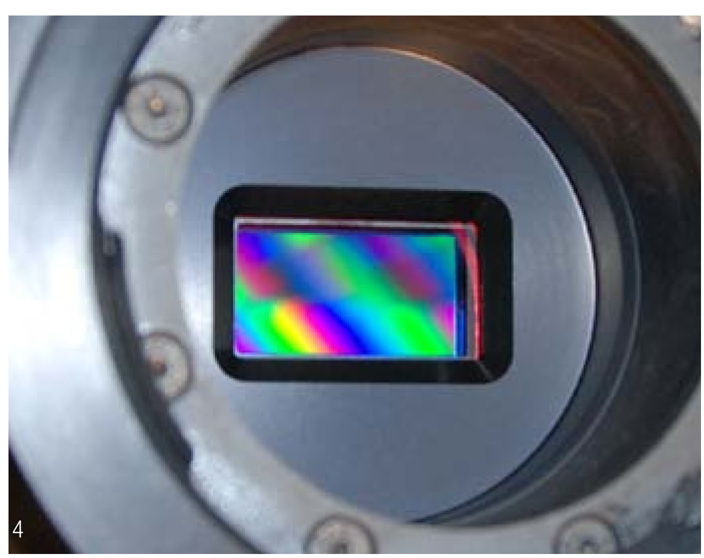
To this day, no one else has been able to come up with an alternative to George Eastman's paradigm of providing a universal, worldwide standard imager. It is also interesting that the format he and Thomas Edison devised over a century ago is still the industry standard: 35mm.

Counterclockwise from top left. 1.ARRICAM gate with 35mm film and mirror shutter. 2. Arriflex D-21 CMOS, 3. Panavison Genesis CCD, 4. RED One CMOS, 5. CMOS sensor fabrication.

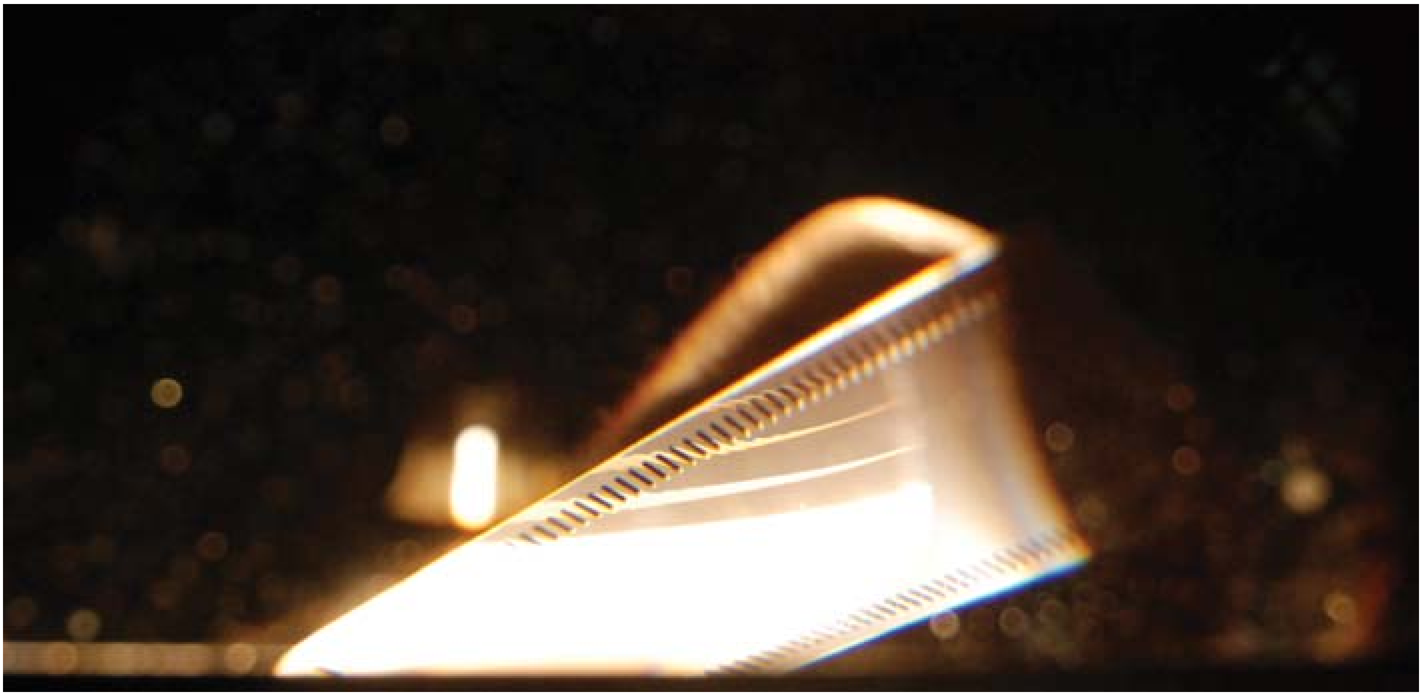


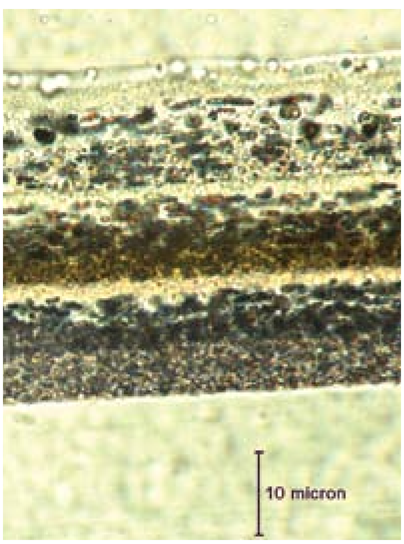




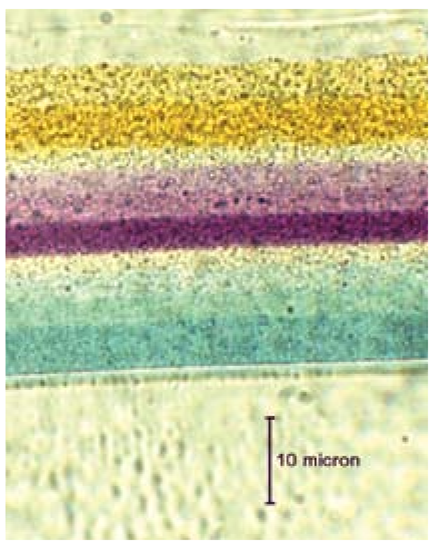


Measured in Microns

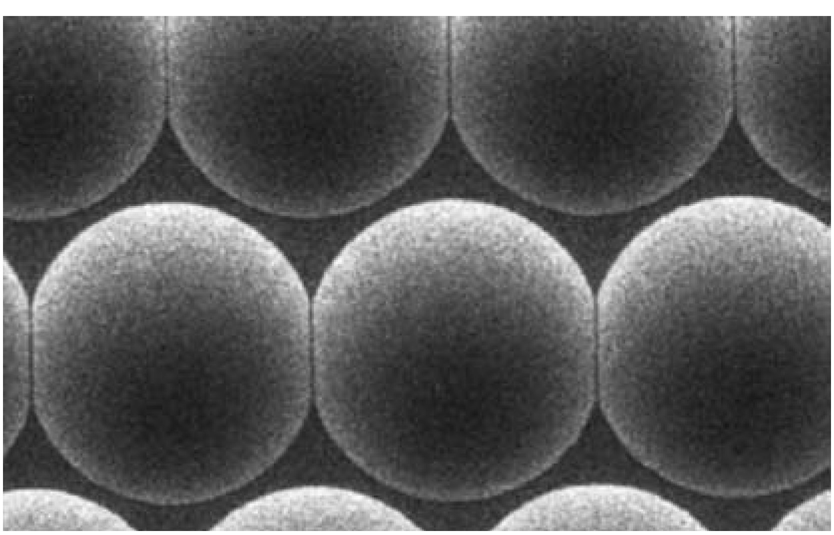




Kodak emulsion: silver halide crystals. Each grain is about 1 µm.



Processed Kodak film: cyan, magenta and yellow. *Below*: Digital sensor, each pixel is about 8 µm.



The grains in motion picture film and sensors in digital chips are currently measured in microns. One micron is a millionth of a meter. A strand of your hair (not mine) is around 50 microns. A silver halide grain in film is currently around 1 micron, and CMOS microlens-photosites range from 4 to 8.5 microns.

There are currently many more grains in an individual film frame than pixels on a digital sensor. Motion picture film consists of an emulsion layer 15 microns thick, a 135 micron-thick base, and a 1 micron anti-halation backing. The "grains" of silver halide crystals are about 1 micron each in size, arranged in layers that form the cyan, magenta, and yellow dyes along with elements that control the properties of the film such as reciprocity, latent image keeping, tonal scale, and color reproduction.

The technology of making sensors, both film and digital, is an accelerating, rapidly evolving, speeding target. Although talk of size, sensitivity and resolution is in the present tense, remember how quickly we moved from Walkman to iPod, from VHS to DVD to Blu-Ray. A few years from now, when 8K monitors as thin as canvas line our walls, we'll wonder what all the fuss was over 2K vs 4K. Sensors will soon be measured in nanometers instead of microns. One namometer is a billionth of a meter: the ratio of a marble to the planet earth.

The recent restoration of "The Wizard of Oz" by Warner Brothers was scanned at 8K, not 4K or 2K, from the original three 1939 nitrate color separation negatives. An earlier scan was done four years ago, at 2K, then the current state of the art. As Rob Hummel, the Wizard of ASC, said, "Film has the capability of storing information we haven't even mined yet."

From Eastman House to Kodak Park

From Eastman House, we drove to the Eastman Kodak campus for an in-depth look at how motion picture film is made. Incredibly, I've been using film all my life, and have been accused by many producers of using so much of the stuff that I was driving up the price per share of Kodak stock—but I had never before made the pilgrimage to Kodak Park. Of course, I had heard rapturous praise from my colleagues about the wonders of Building 38, a place so legendary, it ranked up there with another numbered place, Area 51. The underground storage vaults (above) of Eastman House are as vast as the film warehouse at Kodak Park (below).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Kodak
1669 Lake Avenue

A Cinematographer's Tour of Kodak

left to right:
Garrett Kokx, Mike Ryan, and Martha Lecars on the bridge between building 30 and building 38.

We begin in Building 38, with an engagingly articulate tour led by Garrett Kokx. The following is Garrett's commentary excerpted from the tour itself:

When Building 38 was built 15 years ago, there really were two goals. The first was to make the product as safely as possible. We turned over some of the grunt work to automation, to robots, and let people do the thinking part. Our first priority is safety. Our second priority is to make invariant products to meet our customers' needs. On our tour of Building 38, we'll see many different tools along the way. We'll try to show you things that showcase our goals—safety and invariant product.

Right now, we're actually on the bridge between Building 30 and 38.

Next door is where they make the emulsion, which contains the silver particles that capture the light; the dispersions which contain couplers that form the cyan, magenta, and yellow dyes; and the solutions which contain all the different components that control the properties of the film such as tone scale, reciprocity, latent image keeping, raw stock keeping, and color reproduction. It's all the pixie dust magic that goes in to make each of the film stocks unique and meet all our customers' needs.

The liquids come over in three different kinds of bottles, depending on the liquid amount. And the solid ingredients come over in a black canister. What you have to imagine, whether it's emulsion or a dispersion, or just gelatin, at this point, it comes over and it's like Jell-O blocks that your kids would make in the refrigerator. If you put your hand in, it's cold. It's solid. It's like squishy Jell-O. But it contains the silver and the couplers that we need to make the film.

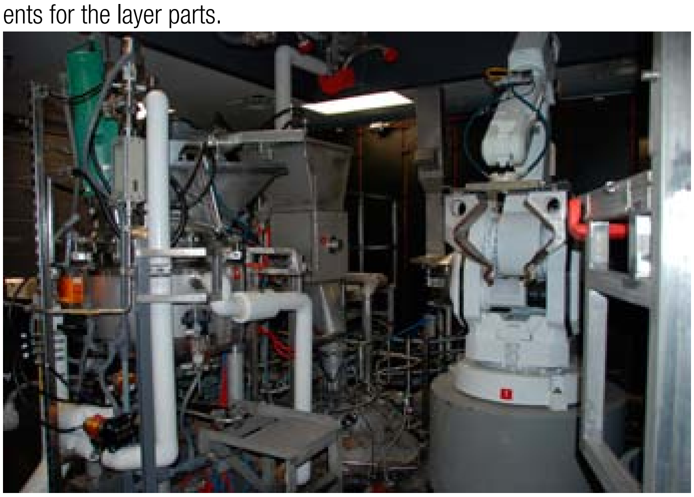
Let's say we're going to make the Vision product tomorrow, the 5219 500T VISION3, one of our most popular camera stocks. We will coat that in Building 38 tomorrow. But today, we have to bring in all the ingredients. We only want to bring them over right before we need them. We don't want things hanging around, because it's all on-demand production.

So we give our order next door to our supply department, and they put those components into containers. And it comes across this bridge.

As soon as we place an order, those things get assembled, and they come across. In older Kodak factories, this job would be done by people, operators, putting the materials on a cart and then pushing it to the destination, often in the dark. But, anytime you're asking operators to push, pull, carry things in the dark, they could get hurt. So how do we avoid that?

Well, part of the Building 38 design was a conveyer system. We have over five miles of conveyer. It brings the material right to the operators so they don't have to do the pushing and pulling. It's much safer. It's more efficient. It also lets us to track the supply chain with barcodes. We scan the barcode on everything so we know exactly what it is, where it is, and what's called for in the recipe next door.

Robots eliminate variability: handling, mixing, and pouring the ingredients for the layer parts.



Every material that comes into our building goes across the scale. And the weight is checked. If the weight is outside our tolerance, an alarm goes off. The process shuts down, and an operator investigates. So, right now, 24 hours a day, seven days a week, we're bringing in materials to go into our factory. We're making sure it's the right stuff.

The end of a line for one of our conveyor systems is what we call an advanced "melter." This is where we make a layer part. As you know, film has lots of different layers stacked on top of a plastic support.

We have layers that are sensitive to red light, green light, blue light. And then there are inter-layers in-between. Each of those layers would be made the day before the coating. Following the "recipe," we bring in the material. And the robot is going to do the work, which eliminates any variability.

Every time we make the fast yellow layer for the 500T or a slow cyan layer, or black and white products, Ektachromes, printed circuit boards, Portra, all the Kodak color negative film in the world—it is all made in this factory. And it's all made with the same process.

Imagine now that we are making a fast yellow layer. And we're in complete darkness. The black cans come in—they have lids on top. They are cans of emulsion. We add each of the ingredients. A robot's arm swings over, grabs the can, and lifts it up where the lid gets popped off. Then the robot arm swings and dumps it into a funnel.

The robot arm swings in and pours chemicals into a funnel.

Remember, it's a solid material like Jell-O. We have some blades in here like a Cuisinart that chop up the Jell-O. And it falls down into a reactor or vessel down below which can hold about a ton of material.

The robot swings over. It adds all of the solid ingredients the same way, one can at a time. As soon as the solids are added, we add water. We turn on the mixer. And then we heat it up and liquefy the gelatin, the emulsions, the dispersions. All those "solid" components that go into the layer get liquefied. Now it's time to follow the recipe and add the liquid solutions.

This time, the robot only uses the small part of its arm, which swings over. It will grab a bottle. The top gets spun off. And then the robot pours it into the vessel. At the right time in the formula, the liquid ingredients then get pumped into the vessel.

This is the tip of the iceberg. Below us is a huge vessel. And that's where we're making up the layer part. So the robot is just going through all of these actions, adding the components one at a time. The key is that we've eliminated the variability. We make the fast yellow layer the same way, each and every time. We tightly control these boring engineering properties — temperature, mixing, pressure, reaction rates.

Then it gets sent to a belt chiller. The liquid material becomes a solid again, and we put it back into the black containers. We add solids. We add water. We liquefy it. We add the liquid solutions. So this is a big, liquid mix—splashing around in there. But it's now the layer part.

We started with the building blocks. We've now made the fast yellow layer liquid. We send it to a belt chiller, which is a long belt. And we spray the liquid on at one end of the belt. It travels along the belt. It gets solidified. At the end, it gets chopped up and put back into the black containers.

So, we start with black containers of emulsion, dispersion, and gelatin. We end up with black containers, each of the different layer parts. That layer part then goes to storage. Congratulations, you've just made one layer. But Eastman Color Negative products can have over a dozen layers. The robot will make each of those different layers and put them into storage. So we'll be ready to coat all those different layers tomorrow.

One thing that's nice about this process is that it's designed for flexibility. After we make the motion picture product, we can make Ektachrome product and we can make a black and white product. It's the same process for each of those different films.

Layers have to be formulated to have certain viscosity properties. We have to engineer them, not only to have the sensitometric properties, but to have those physical properties to be able to coat in ordered layers.

FAM (Finished Advanced Melt) control room, where the layer part making process is monitored.

Now, you might ask, "If we make all these different products on this equipment, what about contamination?" I mean, that's a huge concern, right? Well, as soon as we're done with the layer part, there's a spray ball that goes into each of the devices. It comes down automatically and it sprays out super hot water. It's much like a dishwasher, sprays super hot water, rinses it all out, super hot water, rinses it out. It's an automatic cleaning cycle.

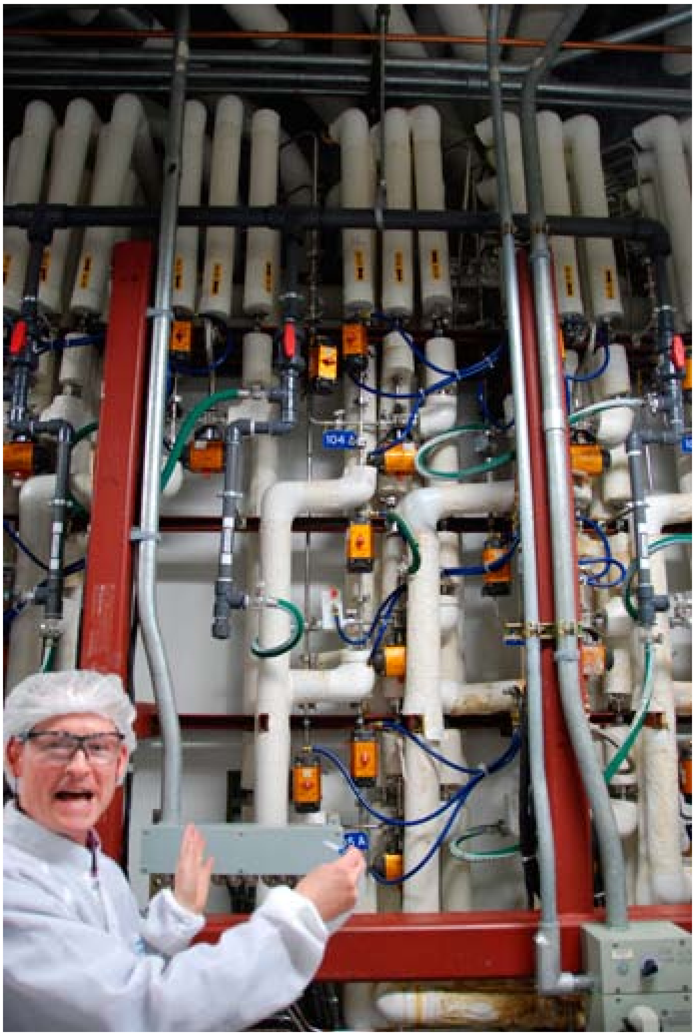
This was part of the Building 38 design. Make it safe, make it invariant. This greatly reduced the variability in how we make a certain layer part. But, how do you know for sure that you're making good stuff when you can't watch it?

It all gets process control. We literally have 100,000 sensors throughout our factory telling us we're making everything the same way each and every time. Even when an operator can't visually watch it, our sensors tell us the robot is adding things at the correct time, the mixer's turning at the right rate, the temperature is tightly controlled so we do it the same way. Process control is the name of the game.

This is the FAM control room. It monitors the layer part making process we were just in. FAM stands for Finished Advanced Melt. We are making a melt-up today to coat tomorrow. We're going to go a day ahead in time. "Yesterday," we were up in the FAM area, making all the different layer parts. All those layer parts were put into storage, this big cold storage area. All those cans are lined up like a library…on library shelves over there. But today, it's time to make some actual product. We're going to make the 5219, coated in Building 38.

In Kodak jargon, we're going to liquefy the 'soup' and pour it onto the plastic. But it's a little more complicated than that. All the solid layer parts are on the other side of this wall. Robots bring the layer parts out, all the different layers for 5219, and bring them to our different delivery systems.
We have multiple delivery systems in Building 38. The robot will dump, and turn the can upside down.

The Jell-O-like material falls down in here and lands on a coil.



Now we're going to start actually coating the material in Building 38. We send hot water through the coil. It liquefies the layer part. And the liquid drips down to a sump. And that gets pumped up to our machine.

How do we make uniform this big kettle of material that takes hours and hours to coat? The answer is to liquefy on demand. As we liquefy the material and it goes to the sump, it gets pumped immediately to our coater and it goes onto the plastic. You no longer have this variability of coating liquid that's hours old, which dramatically reduces the variability of our product.

When we coat, it goes through a filter that can remove any microscopic debris. And then it gets pumped to our hopper. What we have found is that you customers are very picky. When you make an image for the big screen, you don't like air bubbles blowing out your image. You make my life tough! You say to me, "Garrett, you gotta get the air out of the soup." One of our biggest challenges is to get the air out. We have two different devices that use ultrasonic energy to blast the air out of the soup, out of the solution. So what we send up is clean and it's bubble-free.

As we coat onto the plastic, we have to make sure it's smooth and uniform.

Now, you hear fans all around us. You hear pumps. There's all this vibration and energy around us. If that got into the film, it would be ruined. You'd have streaks. You'd have bumps. You wouldn't make a good product.

So when they designed Building 38, they said, "How do we make sure that the coating is as uniform as possible?" Well, they built this pillar of concrete. It goes 60 feet down into the bedrock.

This is the main control room for building 38. It's the brains of the operation. It's where the operators control the process.

It literally is its own building. It's isolated from all this noise and vibration.

≠So, right up above are the hoppers on a nice quiet pillar - isolated from all the noise. It lets us make the most uniform film in the world, roll after roll. This is the main control room for Building 38. It's the brains of the operation. It's where the operators control the process. You remember, upstairs, we had a much smaller control room for just the area that made the layer parts. This is the control room where we actually coat the product.

This'll be pretty neat, we'll go right in there, and we can watch the start of the coating process. Look at all those movie posters on the wall. I think they really reflect some of the pride that our operators have. Every movie that was shot on Kodak film, starts in this factory.

This is the only place in the world that makes Kodak camera origination and intermediate motion picture film. Building 38 makes all the different products, including every single frame of your camera origination film, it's made right here. If you're shooting in Europe, it's still made here in and shipped there.

What we're going to see next is the hopper. What do I mean by "hopper?" Remember, we're going to actually coat the soup onto the plastic next. So all the layer parts are coming up. Downstairs, there's a delivery system. And it comes up and there's this metal device called a hopper. It looks like a child's slide. It's a metal sheet that angles down above the moving plastic film. Each layer comes through a thin slit in the hopper. The liquid comes out of the slit and goes down the slide.

It's a liquid. It's rolling down the slide. It gets to the bottom edge of the slide. And then it falls off as a waterfall. This is a revolutionary design, in that the plastic is actually unrolled below the liquid, and we have this waterfall layer effect. Now, what do you think happens when it hits the plastic? It splashes.

It's a waterfall, Like Niagara Falls. Niagara Falls would not be good in our factory. It would make a huge mess. So instead, Kodak scientists and engineers designed the waterfall so it falls and it hits the plastic and it just coats the plastic. You have a waterfall, which comes down, hits the plastic and spreads out. There's no mixing. There's no splatter. There's no splash.

There isn't just one layer. There are multiple layers coming down on top of each other. That's why there are multiple slits in the hopper. And that's why, we talked about it earlier, we have to formulate those layers so that they come down together on top of each other and don't intermix. We have more than a dozen layers in a motion picture product. All these different layers come up through the hopper.

They don't have to wait for one to dry, and then the other. This is the magic. You have a liquid flowing down the slide. Then, you have another liquid behind it. Each liquid sees the other liquid. Normally, they would mix. That would ruin our film. Kodak scientists used properties so they stack on top of each other in a liquid state. It's like one of those drinks with the different layers, like a Pousse-café or B-52. The only thing we're missing is the umbrella on top of the glass.

This technology is called waterfall coating. It enables us, again, to make product that was much more consistent. Kodak scientists have made careers out of designing the equipment and the emulsion layers so they stack up. This is part of the partnership between manufacturing and research and development.

When they develop the next VISION3 products, they are formulating for this process. Working together, when the scientists develop the next technology for new film, those guys are right in here with us during the coating events. R&D doesn't just say, "Here, manufacturing. Good luck." We're definitely partners in each new film. The key to Kodak is not only the image science technology, but it's the materials science technology that goes into the manufacturing that allows us to produce these products at the speeds and the volumes we need.

Next, the coated product goes to a dryer. And at the very end, it gets wound up in a big master roll. For motion picture, it's about a mile long. Here's another neat aspect of our building. You've probably been into a processing lab where you see the film go through a processor. Lots of rollers, lots of contact. And every time a roller touches our film or your image, you can get dirt, you can get scratches.

When Building 38 was designed, we asked, "How do we minimize that contact?" As much as possible, when we take our film "web" through the machine, we don't want it to go up and down like this with rollers. Instead, it's conveyed by air. It's like a magic carpet ride. There are air jets on the bottom and on the top. And the film just floats on that air as it goes through the machine. Of course, there are a few locations in the machine where it has to touch a drive roller. But, as much as possible, we use air to convey it to minimize any scratches.

You are here for the historic last coating of our 5205 product, because VISION3 5207 has replaced VISION2 5205, 250-D. You don't have to remove your hat, but there may be a moment of silence. A long time ago, different products were made in different coating rooms here. And when this facility came online, some of them had to be reformulated to be made in this building. 5293 was the first product to come up in here.

Well, we're almost ready to go. The operator's checking to make sure there are no lines, no streaks, no bubbles. Now the hopper is moving into position over the plastic support. There's the waterfall. It's not Niagara Falls. There's no splash and splatter, no drama. The different layers, all the soup that comes down the slide, falls together and then the layers all line up right on the plastic. Then they get sent to a dryer where we pull the water out of the film. By the time it gets to the next coating station, it's dried. And we'll put the next set of layers on it.

So it's a continuous path, first to one coating station, then to the next, and then to the winder. Now one of the questions that folks ask me is, "Hey Garrett, this roll of film, how do you know it's good?"

Well, every single roll that we coat, we take a sample. And we test it for sensitometry, making sure the tone scale and the speed is correct. We look for any physical problems. So we have this little sample. The next logical question is: you've looked at this little sample, how do you know that the whole mile is good?

Okay, so I tested the beginning and the end. But how do I know the middle's good? It's all about process control. There are 100,000 sensors that tell us we're making it the same way, each and every time, every parameter is tightly controlled. If you're looking at the end and you're looking at any place in the middle, it's all the same. Because the process is the whole key to an operation. We want to avoid testing and adjusting. We don't want to tweak things. We just want to lock them in, and make it the same way every time forward.

But, the real key to our operation is the staff of Kodak workers who are here 24 hours a day making the product. You can have all the whiz-bang technology in the world, and none of it matters if you don't have dedicated trained people. These are the folks who run the show. In the end, this is their quality. They drive the process. When we design new products, we have manufacturing as our partners in the process. So we make sure we're designing it to be manufacturable. If there are issues with the current product that have developed over time, we're trying to take care of them with the new products. Or we're trying to formulate the coating properties for the new products to be as similar as possible to the old products so that they coat in the same manner, but we can design all the new features into them. It's all about working together, making sure that we are working on whatever current customer problem or manufacturing issue we might have.

Next stop: we're going off to finishing.

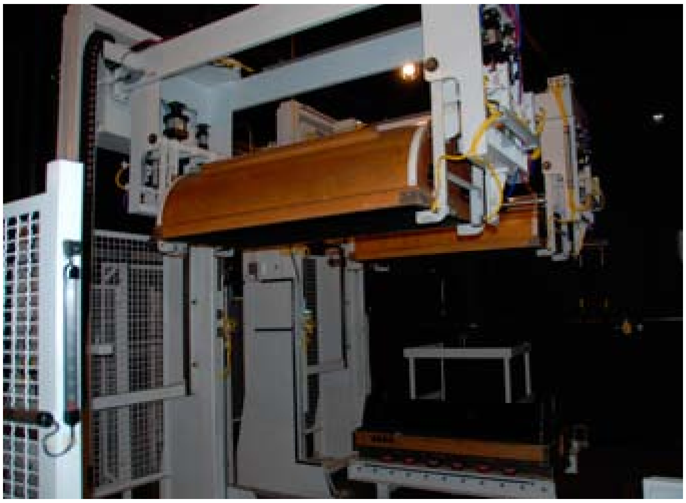
We exit Building 38 and hop into Mike Ryan's SUV for a drive through the Kodak campus, past building after building the size of several football fields. Arriving at Kodak's finishing building, we meet Bill Fekete. The following is Bill's commentary excerpted from his portion of the tour:

Welcome to the finishing facility. My name is Bill Fekete. And I'm the quality engineer for Entertainment Imaging, film finishing. So in this building, what we do is all the film finishing for all of Eastman color negative, Eastman color intermediate, black and white, motion picture, and most of the finishing for Eastman color print film for all of Kodak. From beginning to end, from the time it starts getting prepped till the time it goes into a can ready for shipping takes about a day. The origination film is usually acetate. The print film is usually polyester. They're all finished here.

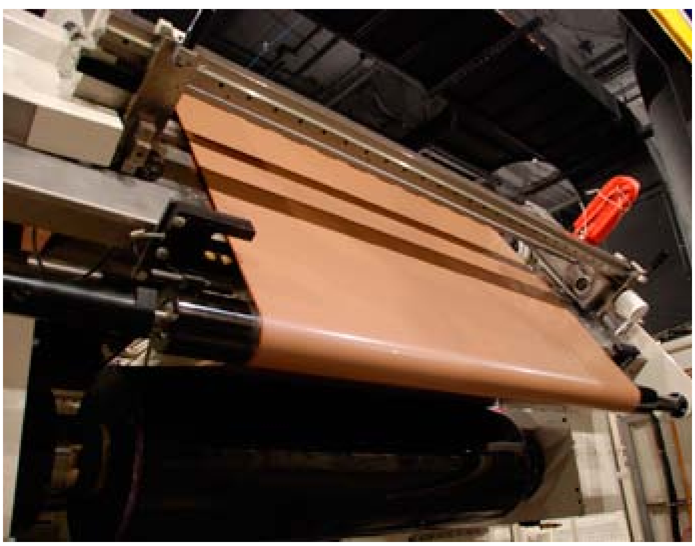
We are now at the Film Finishing Slitter

We use wooden containers where we put in what we call a master roll, 6,000 feet of film, four and a half feet wide, one master roll that then gets sent to finishing where they slice and dice it into 16, 35 millimeter, 70 millimeter, whatever different sizes our customers want. The finishing includes slitting. We get the wide rolls that Garrett just showed you. They come here. We slit it down to final width.
Then, of course, we perforate the rolls and they get cut to the final length. Then we do the final packaging.

And it gets shipped from here, some directly to customers and some to warehouses. From there it goes to different customers and winds up in your cameras.



The 6,000' master rolls are removed from the containers (in the dark) and prepared for slitting.



A standard slitter is pretty much a machine that you could use for anything; toilet paper, paper towel, aluminum foil, plastic wrap, video tape. They all take wide rolls of something and slit them into narrower ones. The Kodak part of it is all within our special knives. How we actually cut the film is our unique technology.

Anything that you want to coat, big, wide stuff, and then get it down to different widths, you're gonna slit it. We have specialized knife edges because the way film cuts--of course, polyester cuts one way, acetate cuts another. We're making both these films here. You have to cut the film in such a way that you're minimizing the amount of cutting debris that you make, because you don't want dirt. It has to be clean. And then of course it also has to be invariant. You don't want your edges moving all over the place.

Your absolute width is critical. You don't want some narrow, some wide. Even though the emulsion is dry, the consistency is like cream cheese. So imagine, cutting a pie. But you have to cut through that. And then you have to cut through this really hard thing underneath. And you want to make sure that whole edge is straight, and one doesn't end up cutting like this, while the other one cuts a different way.

The wide rolls come in covered boxes. Movement of the wide roll is all automated. On the outside is the identification for the roll. It's a barcode. And once the information is read it's downloaded in the computers. So from then on, it's all automated. So we know exactly what film it is at all times. Each one of these locations is attached to a computer, so it knows, "Okay, I know what that wide roll is." Of course this is all in the dark. It gets loaded right on the slitter. As soon as it's loaded, the slitter now knows, "Okay, I've got this wide roll. It's this product. It's this emulsion. It's this code. I'm going to cut it to this length."

The 6,000' master rolls are removed from the containers (in the dark) and prepared for slitting. Each roll of color negative film is about four feet wide by six thousand feet. (Print film is 12,000 feet.) They're really big rolls. And then we slit the whole thing.

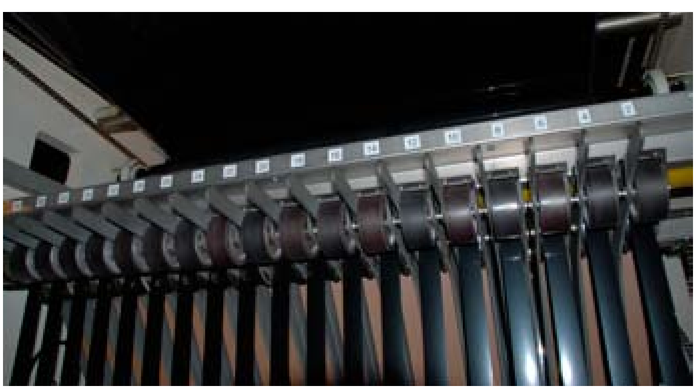
We are now in a perforator room. Here we have what we call our "T" perforators, very high speed. We follow the SMPTE specs...but we usually end up a lot tighter than that.

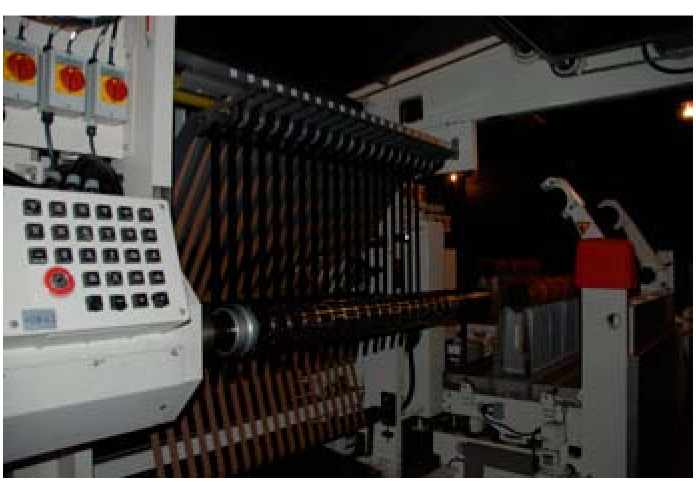
Right behind this wall is our rack of film. This came from the slitter. We've got a rack of 6,000-foot rolls. There would be 19 rolls of them on the rack. They're either odds or evens. Normally we get 6,000 feet. And then the operator has to make a splice to the previous roll. Then we start by running the splice through the machine. That gets removed. And that piece of film represents what we call our end test. So for every single slit we get a ten foot sample. And that goes to the lab. And I'll show you what we do with it in there.

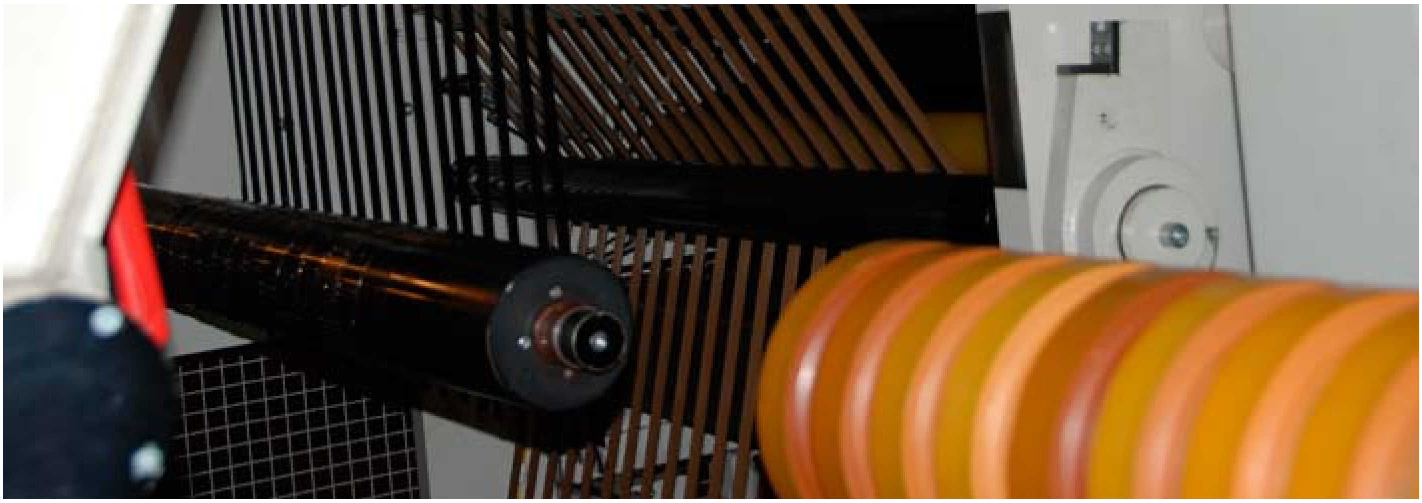
We have an auto-cinching mechanism that will actually take the film, wrap it around the core, and then the machine starts up. This machine knows what the final product is. And it's going to cut the film down to the final length.

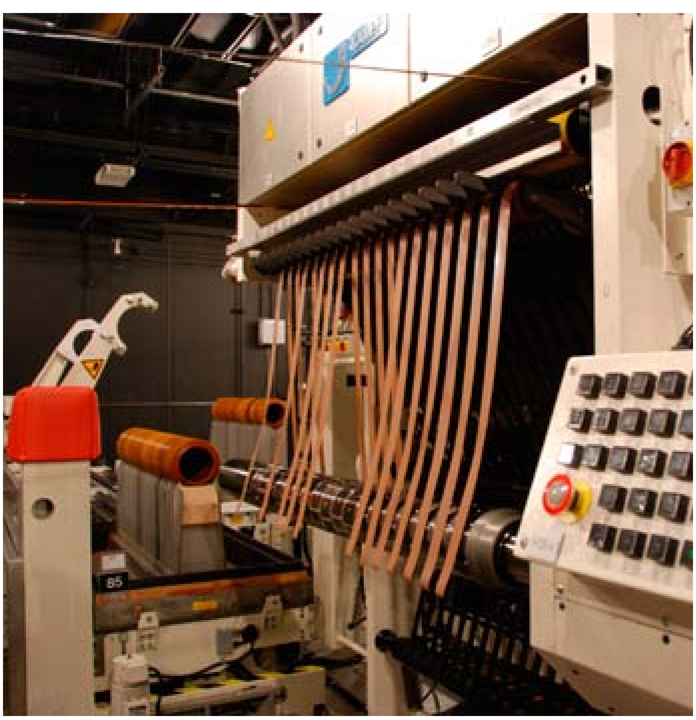


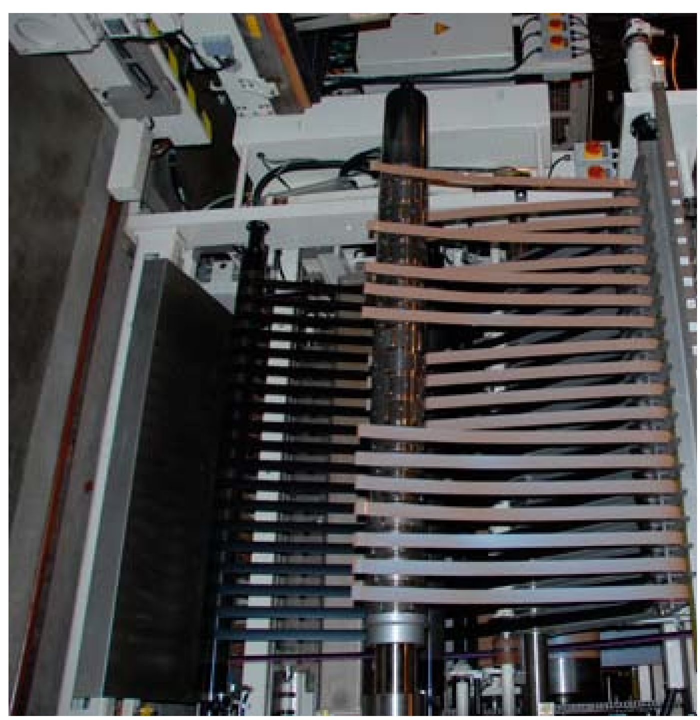










The perforating machine.

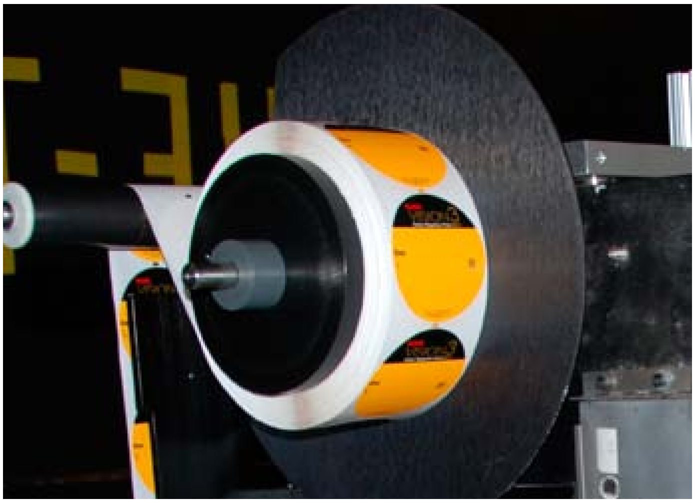
I have a 6,000-foot roll here. If this is 400-foot product, it'll perforate 400 foot. That gets removed, and then it'll just keep doing one after another. The actual perforating is done right here. This is what we call our heart. As the film goes through, the punch and die engage and punch a hole. There is a vacuum tube, where all your perforations are going, over to the bend at the end. So they are getting sucked out continuously.

There is a vacuum drum here, because we don't have any sprockets at all in this machine. It's all driven by vacuum drums, so we're not damaging the holes throughout. When a customer gets the product, all these perf holes are perfect. They've never been touched.

After this, the film goes across four PTRs—Particle Transfer Rollers. We have four PTRs, two on the emulsion side, two on the support side. Particle Transfer Rollers are designed to collect debris. You'll see them on all the equipment at labs like Technicolor and Deluxe, and also high-end projectors have them in theatres. They don't really feel tacky, but believe me, they pick up particles, really small, fine particles. We're worried about anything bigger than, say, 20 microns. We want to get it.

After every single slit gets perforated, 6,000 feet, these PTRs disengage and go against this tape. So we clean them. We're constantly cleaning things so we never build up a lot of debris on this surface. These tapes then act as a quality control device, because we send these tapes to the lab. They'll unroll the tapes and look for any unusual amounts of debris. If they see all of a sudden there are a lot of particles, they'll stop the machine, say, "You got a problem," and then tell us maybe our tooling's wearing out, or maybe something got caught in the machine.

Perfs are recycled. Carefully: very sticky, and lots of them.



Labels, cans, tapes, testing.

So again, that's all the information that comes in on that slit. It's also telling the key code printer, "Okay, you've got this code, emulsion roll. It's this film. So you're gonna have to expose it with, you know, this much time on the red LEDs and this on the blue and this on the green," and the whole bit. Right here, we put the film in a bag, put it in a can. And then that's a labeler. We're getting the label right here. Before the next roll is done, this one's already fully identified.

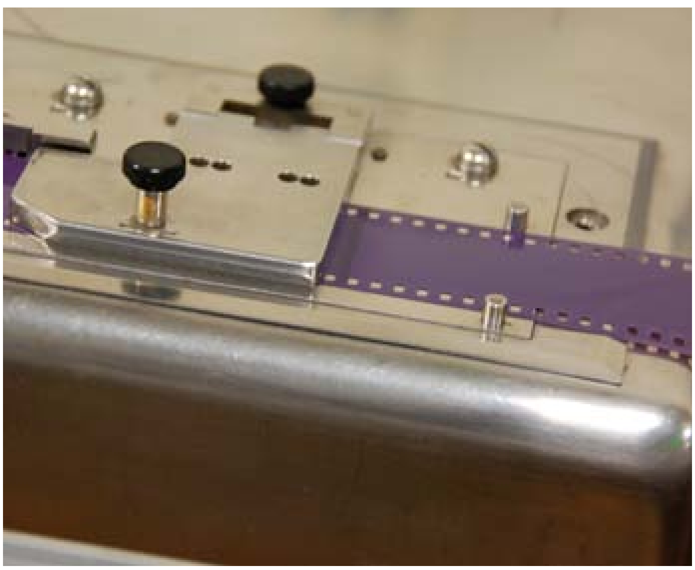
We are now at the packaging line where we apply the top label, and the bottom label at the same time. It's just our disclaimer that says, you know, dyes can fade over time. And then the tape is applied here, too. And on the tape we print the code, emulsion, and roll right on the tape.

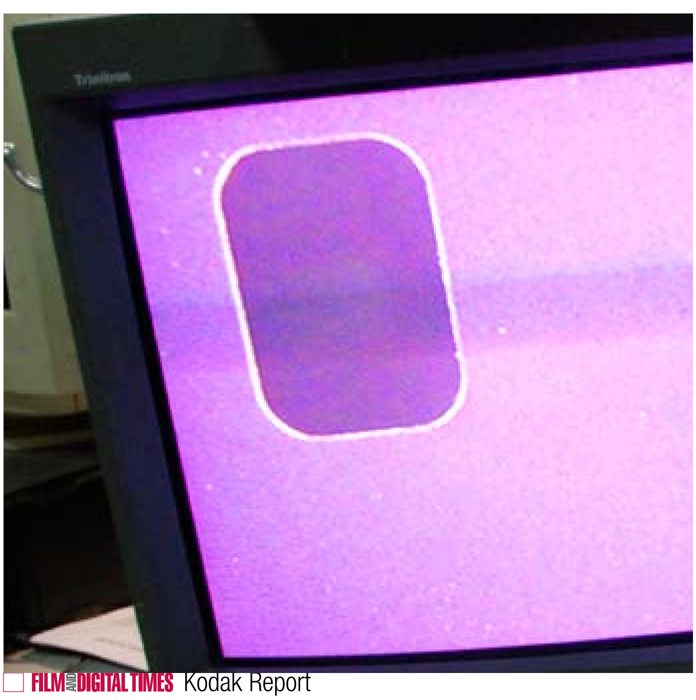
We are now in the quality control lab. You're familiar with the letter designation for all the dimensions. You have B dimension, which is the pitch between the holes, C dimension, which is the hole width. D dimension's the hole height. And then there's a measurement of the margin. We take a long sample of film, cut it into pieces, put one in each gauge and run them all at the same time. We do that pretty regularly, just to make sure all our dimensions are in tolerance.

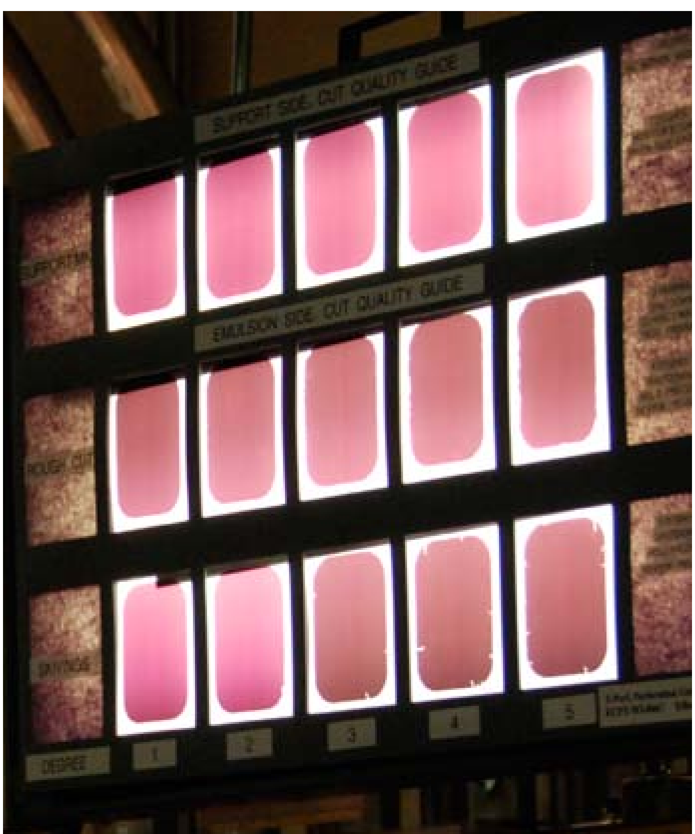
We do a lot of testing.

We take raw film, unprocessed, right from the perforator, put it on the projector. We project the image of the perforation onto this camera. This is a 2 CCD camera. You've got one that's looking for horizontal movement, one that's looking for vertical movement. And we actually measure the amount of movement in both directions. And then again, we apply a formula to it so that we can look at any kind of repeats that might be coming from the machine if a roller is a little out of round, or something's going on. We can pick that up right away.

Our specifications for those are all internal, because there are no SMPTE specifications around for that kind of movement. We've had to develop all of our own just based on customer feedback and extensive testing.



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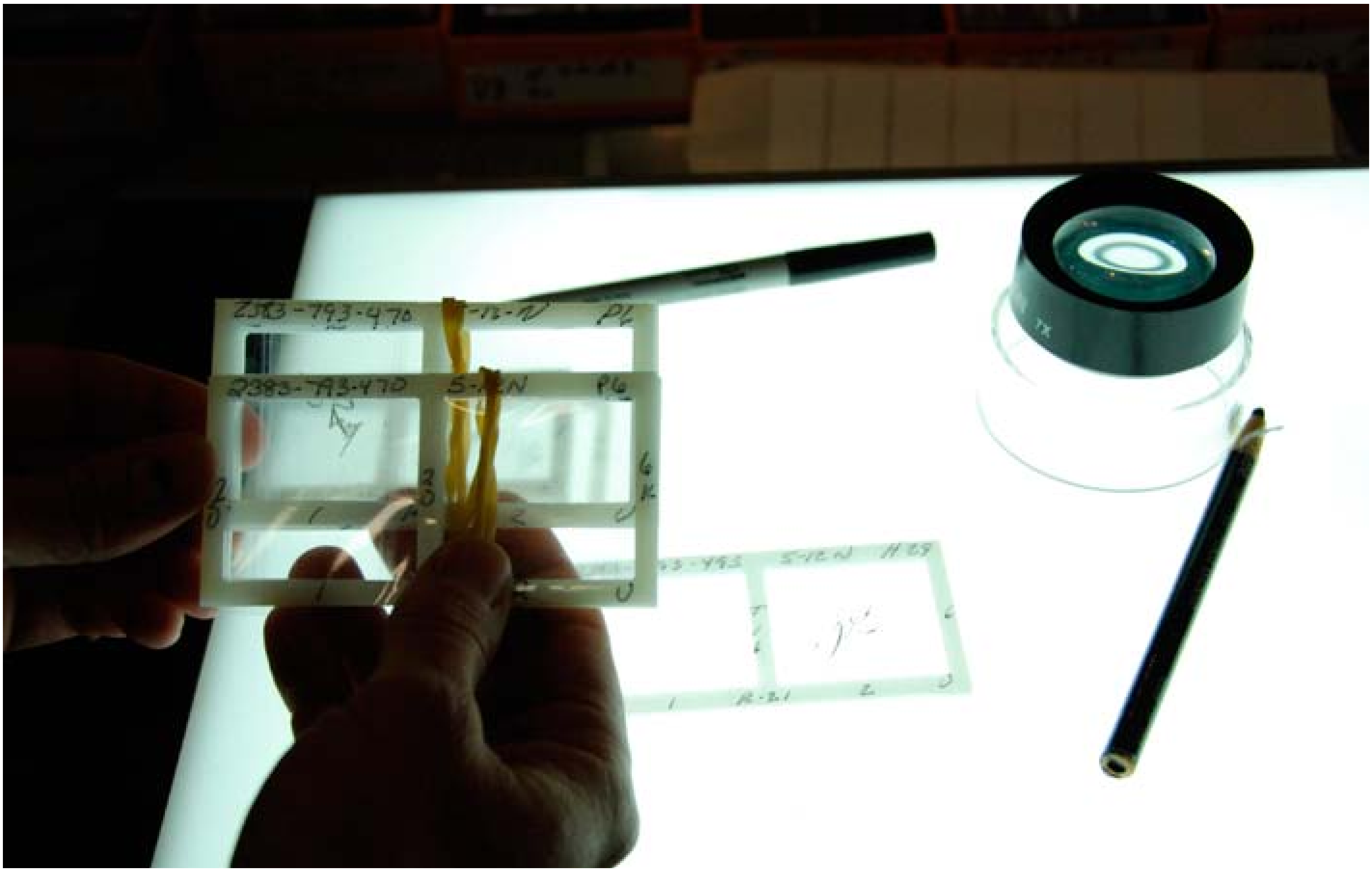
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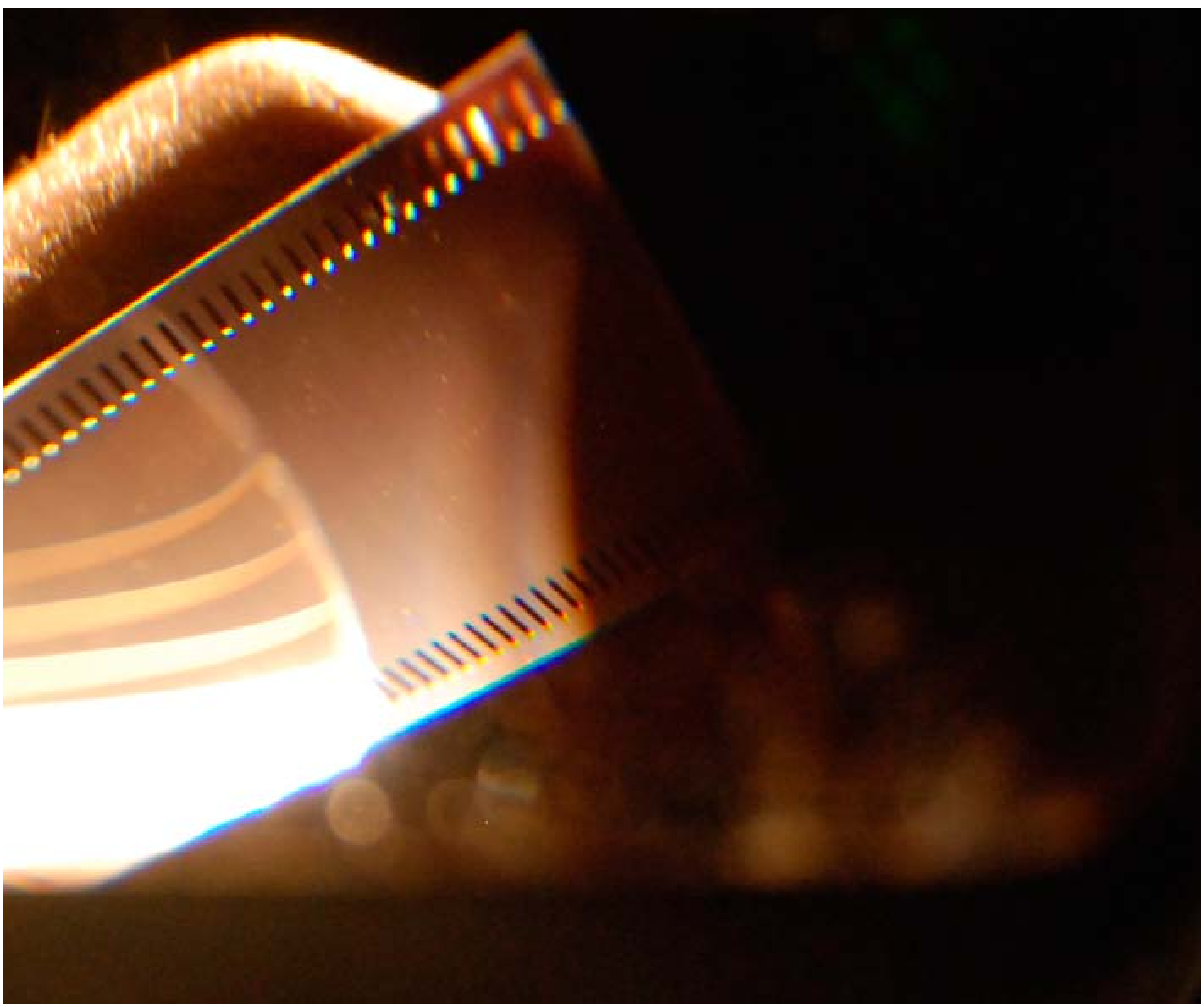
At the end of our tour, we meet up with a Kodak scientist, whose credits read like a 'Who's Who' of film research and manufacturing. He said, "One of the things that we benefit from is visits from customers like yourself...who use our film. However, your cycle of being on a project is relatively short compared with ours. We don't want to give you a film that you will shoot on one project, say, "That's the best film I've ever used," and then the next time you're shooting a production say, "Where did that film go?" We usually go through a platform in five to six years: the EXRs and the Visions, the VISION2, VISION3.

We had a distinguished ASC cinematographer here once. And he said, 'Why you guys always keep coming out with new films? I gotta learn this new stuff.' He was, maybe, 85 and still working all the time. We like to joke that you cinematographers often tell us, "All we need are two films."

But the funny thing is that every one of you have a different two. That's why we have so many emulsions—and they're all made here—in Building 38."



Kodak

Motion Picture Film

This report could never have been written without the generous time and hospitality of:

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